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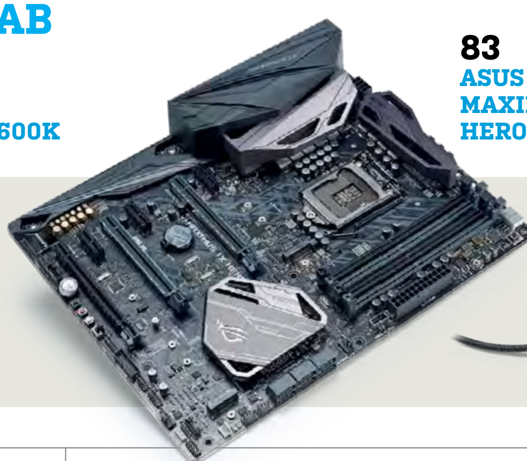

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Tuan
Nguyen

THE TRUE TEST OF A SKILLFUL PC BUILDER

WITHIN THE WALLS OF OUR OFFICE, people often say "go big or go home" when it comes to building a system. Multiple graphics cards, unnecessary amounts of memory, and irresponsible volumes of storage space. And while it's fun and entertaining to build monster systems, there are times when a compact, practical, and affordable system can equally be a beast in a different manner.

People generally try to aim for the $700 mark. For the most part, this is a good price for a budget system. A cheap build may come in at $500, which is pretty svelte when it comes to keeping money in your pocket. So, what if it were possible to have a full-fledged PC that is as potent as it is thrifty?

When money's no object, things actually become fairly easy. Pick the best parts or choose the most expensive stuff you can get your hands on. It's a greater challenge to be strategic about component selection in order to achieve a low price. How low? We're talking an obscenely low $300.

Building such a system, however, requires a bit of careful planning, not only in parts selection, but prices, discounts, and other factors. You basically have to put on a bargain hunter's thinking cap, and be smart about how and where to source your parts. Shipping charges are accounted for. Rebates are tallied. And price-history tools are an invaluable asset with which to arm yourself.

Once you've mastered the art of being frugal, it's time to learn how to squeeze the most performance out of the system. Everything matters, and learning how to control what goes on when you're using your PC is critical. Which is why we show you how to dish out an exacting command of Windows' Task Manager.

Often overlooked, Task Manager is more powerful now than it has ever been. Sure, you can use it as a tool for seeing system load and resource usage, but it can do so much more. We show you how to control individual processes, and how to give jurisdiction over their utilization of your CPU's precious cycles. Then learn the ins and outs of services and start-up applications, so you can ensure nothing is running that isn't needed.

Due to the nature of our jobs, our team of editors is often swimming in pools of hardware. We're always just an arm's reach away from some piece of gear that, by itself, costs many times more than our challenge build. Have I ever built such a system myself? Yes, but not nearly at the skill level that Zak and Alan exerted this issue. The cheapest system I ever built was a measly $600, which doesn't even hold a candle to their builds. If I were to build such a system, I would more than likely hunt for pre-owned parts—which is absolutely acceptable, and is actually part of timing your purchases.

There's little doubt that a $300 system will deliver maximum value for maximum savings. Go small or go home.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Ryzen: The First AMD Zen Chip

Is AMD finally going to get its competitive edge back?

THIS IS AN IMPORTANT release for AMD. Yes, every processor launch is important, but AMD's Ryzen chip is the first to feature its Zen core architecture. This is AMD's first serious assault on the high-end and enthusiast market for five years, and there is an awful lot riding on its success. Ryzen is an eight-core barnstormer, built using a 14nm production process. Intel chips have been top dog in serious machines for a while now—AMD fanboys will tell you how AMD chips can run faster, but it always seems to require a specific set of circumstances to achieve the trick. Ryzen looks to have the raw power to tackle Intel's finest across the board.

The Zen core architecture is a clean-sheet design that's been cooking since 2012. The development team has been led by Jim Keller, the man behind the original Athlon architecture (which was great). Highlights from the feature list include a write-through L2 cache, simultaneous multithreading (at last), and a clever new branch prediction system. This has AMD claiming there is a "true artificial network inside every Zen processor." A trifle optimistic, perhaps, but we get the idea, guys: It's better at predicting. AMD claims that all this trickery gives Zen a 40 percent instructions-per-cycle improvement on the previous Excavator architecture.

To enable more flexible and effective DVFS—Dynamic Voltage and Frequency Scaling—Ryzen is fitted with a matrix of embedded sensors to monitor temperature, frequency, and voltage. This enables more effective management of power consumption, and a new system called Precision Boost. This works seamlessly to ramp up selected cores in 25MHz increments. More interestingly, though, we also have XFR—Extended Frequency Range—which will enable higher clock rates if the system detects sufficient cooling. Sounds like automatic overclocking, doesn't it? Effectively, it is.

Early benchmarks using engineering samples, and AMD's launch presentations, have been tantalizing. It shows itself as a match for the mighty i7-6900K across a range of benchmarks, including some awesome 60-plus fps 4K gaming. Count us impressed. Early indications (all right, then, leaks from the fabs in China) have four Ryzen chips ready for launch early in the year. The 3.4GHz SR7 and SR7 Black Edition are the range-toppers, with eight cores, 16MB of L3 and 4MB of L2 cache, and an impressive TDP of 95W. A six-core SR5 and a four-core SR3 are to follow.

All well and very good so far, but the clincher is the pricing. The SR7 is "expected" to retail at $349, and the lovely tinkering-friendly Black Edition at $499 (all prices are a little fuzzy as yet). That's near enough half what Intel will charge you for a comparable Core i7. The SR5 and SR3 are similarly attractive at $249 and $149. That last price puts it into Core i3 territory.

The SR7 Black Edition will probably grab the early headlines. It is a "3.4GHz+" chip. How far that "+" can be stretched is going to be fun. To 4GHz on all cores and 5GHz on a single core without liquid cooling, if the rather over-excited early testers are to be believed. Ryzen has the dream combination of effective multithreading across multiple cores and decent clock speeds.

Even allowing for the expected huff and puff from AMD and its fans, Ryzen is going to put AMD back on the map in a big way. The next few months are going to be interesting times indeed. If you are planning a new rig in the near future, it looks like the "AMD or Intel" decision just got real again. **–CL**

> XFR will enable higher clock rates if the system detects sufficient cooling.

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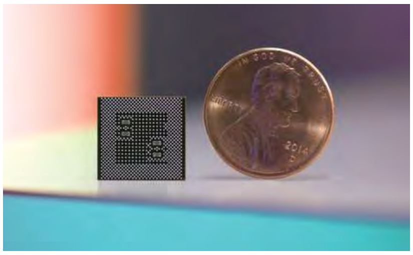


SNAPDRAGON AIMS AT VR

New high-power mobile chip drives smart glasses

QUALCOMM HAS LAUNCHED a new flagship processor, the Snapdragon 835. It's the first the company has built using a 10nm process. It has eight cores, four running at 2.45GHz and geared for performance, and four running at 1.9GHz and configured for efficiency. The company claims a 27 percent improvement on performance, and, more importantly, a drop of up to 40 percent in power consumption—although not at the same time. The new Adreno 540 GPU is 25 percent faster and now supports 10-bit 4K screens at 60Hz, which is pretty good going under any circumstances, let alone for something this small.

Much of the work has been geared toward improving VR, including eye-tracking in hardware, and support for Google's Daydream VR. One of the first bits of gear to use an 835 comes from the Osterhout Design Group. It has produced two smart glasses: the $1,799 R-9, with an 1080p display, and the 720p $1,000 R-8. They both run Android and can display augmented, virtual, and mixed reality overlays. The company is best known for making headsets for the US military; this is its first foray into consumer sales.

The glasses are quite chunky and weigh in at 6oz and 4.5oz respectively. They might look cool enough in studio photographs, although whether you'll look so cool walking around outside is another matter. Google Glass trod this path before, of course, although with much cruder hardware. It had all sorts of problems, not least concerns about privacy with the front-facing camera, which these two also sport. It does show what a powerful graphics engine the 835 has, though. We can expect to see this very capable chip in phones, mobile VR, and other tasty gadgets in the course of the year. Which is good for Qualcomm, because it has just been handed a $865 million fine by the South Korean Fair Trade Commission, for violation of anti-trust laws. **–CL**

WINDOWS GETS GAME MODE

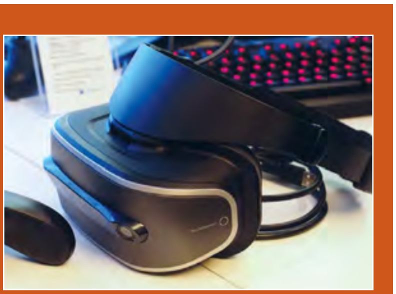
BUT ONLY IF YOU BOUGHT AT THE WINDOWS STORE

IT LOOKS AS THOUGH the forthcoming Windows 10 Creators Update will include a new Game Mode, as sharp-eyed beta testers have noted a file called gamemode.dll. Nobody is exactly sure how it'll work, but some sort of tweaked resource allocation that gives the game more attention and shuts down background tasks looks likely. Similar to the way the Xbox One works, which makes sense, as they share so much code these days.

The plot thickened, though, when it emerged that it's also likely to only work with Universal Windows Platform games, so only those bought through the Windows Store. The Windows Store is not massively popular as yet, so any incentive Microsoft can offer will help, but it's tough for Steam users. It certainly shows how serious Microsoft is getting about gaming on the PC, and tying the PC and the Xbox together. **–CL**

LENOVO VERGE ARRIVES

Decent spec and budget price



VR HAS BEEN "this year's big thing" for years now—it's almost getting ridiculous. What it needs is decent and affordable hardware, and widespread support. Microsoft's Holographic platform could be one half of that equation, and Lenovo has launched a new headset, which could be the other. The Verge is a lightweight headset; the company is aiming for a commendable 350g. It sports two 1440x1440 OLED screens, which are suspended in front of your eyes, rather than strapped to your head, as with the PlayStation VR.

Since the system doesn't require external cameras for head-tracking, the price has been kept down. An exact figure has yet to be released, but Lenovo is talking of under $400—closer to $300, in fact. The Verge is lighter, has higher definition, and is cheaper than the big two rivals, the HTC Vive and the Oculus Rift. Maybe this year really is *the* year.... **–CL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

SMART HAIRBUSH, ANYONE?
The Kerastase Hair Coach can detect how you brush and the condition of your hair, with all the data transmitted to your phone.

FOLDING PHONES
It looks as though Samsung's new Galaxy X will come in a folding screen version—the return of the flip-phone?

FLASH REACHES 2TB
Kingston has released a chunky 2TB flash drive, the DataTraveler Ultimate GT, the world's biggest yet.

TRAGEDIES

CURSING TOYS
Parents have been complaining about their child's Hatchimal's language. It is supposed to be saying "hug me."

PHONE SHUTDOWN
Some Google Pixel phones are shutting down when battery capacity hits 30 percent, and refusing to start until charged.

MICROSOFT IS SORRY
"We knew that we had gone too far," admits top executive over Win 10's aggressive update reminders.

Jarred Walton

TECH TALK

Looking Forward to AMD's Vega GPU

AT AMD'S TECH SUMMIT in December, we got some concrete details and demos for Zen (now Ryzen) and Vega. Ryzen should be available around the time you're reading this, but Vega is further out, with a release target of "first half, 2017"—probably June/July, judging by AMD's past history.

Along with working silicon, AMD provided the first official details on Vega, and it's shaping up to be *(ahem)* out of this world. It builds on everything that makes Polaris great, but it's not simply a bigger chip with more cores. AMD didn't provide Vega's core count or clock speed, but it will likely be 4,096 cores clocked at around 1.5–1.6GHz. The reason we can be so specific is that AMD also announced a new line of machine intelligence accelerators, called Radeon Instinct MI6, MI8, and MI25. The MI25 uses Vega, and will provide up to 25 TFLOPS (with FP16—half that for FP32), which means Vega should be 45 percent faster in gaming performance than the Fury X.

But it's not just about TFLOPS. AMD has reworked several elements of its GCN architecture, a major one being the memory subsystem. Vega includes 8GB (possibly 16GB) of HBM2 memory in two stacks. These deliver the same 512GB/s bandwidth as the four stacks of HBM1 in Fiji, but with two stacks, the silicon interposer doesn't need to be as large. AMD isn't just calling this HBM or VRAM; it's now a High-Bandwidth Cache (HBC), and there's also a new High-Bandwidth Cache Controller (HBCC). The distinction is important, because the HBCC plays a much more prominent role in memory accesses.

AMD profiled VRAM use for *The Witcher 3* and *Fallout 4*. In both, the amount of VRAM allocated is two to three times larger than the amount of VRAM accessed. The HBCC takes this into account, allowing the GPU to work with far larger data sets, with a 512TB virtual address space. AMD also demonstrated a real-time physically rendered image of a house using more than 600GB of data, running on what I assume is an 8GB Vega card. If the HBCC works properly, even a 4GB card could behave more like an 8–12GB VRAM card, while an 8GB card would equal a 16–24GB one.

> If the HBCC works properly, a 4GB card could behave more like an 8–12GB VRAM card.

AMD called this mockup of four Vega modules with 100 TFLOPS of compute a "brain-in-a-box."

Vega also has a new geometry pipeline. AMD notes that there can be a 100x difference between polygons in a scene and those that are visible. The new geometry engine will have over twice the throughput per clock compared to AMD's previous architecture. The compute unit is also improved, with native support for packed FP16 operations, which should be useful for machine learning applications. AMD's Mike Mantor also stated, "We've spent a lot of time tuning and tweaking to get our frequencies up significantly and power down," though the Radeon Instinct MI25 still has a "<300W" TDP.

Finally, AMD improved the pixel engine, with a new Draw Stream Binning Rasterizer that helps cull pixels that aren't visible in the final scene. All the render backends are also clients of the cache now, reducing the number of memory accesses. This should provide significant performance improvements with deferred rendering engines, which is what many modern games are using.

Based on performance numbers, Vega would be impressive, but factor in the other changes and AMD's DX12/Vulkan performance, and we're looking at another exciting year in graphics cards. The GTX 1080 leads the Fury X by around 35 percent (less at 4K), so a 45 percent boost would put Vega well ahead, and if the architecture improvements can add another 10–15 percent, Vega might even exceed Titan X. For graphics junkies like me, June can't come soon enough.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

Alex Campbell

OPEN SOURCE

The Next Big Linux Fight is Flatpak vs. Snaps

ONE OF THE BIGGEST PROBLEMS with Linux has been the duel of competing standards. The battle between Flatpak and Snaps wants to take the fight between package standards beyond the distro. Back in November of 2016, the Fedora project came out with version 25 of Fedora Workstation, and with it came official support for the Flatpak package format, which promises to unify package software distribution.

The problem is, Canonical said the same thing with Snaps when it released Ubuntu 16.04 in April 2016. So what gives? First, it helps to know what exactly these new formats look to accomplish. The "purest" way to get software on a Linux system is to compile it from source. But compiling from source is a huge pain in the butt, and takes time. Which is why most people prefer to download packages.

Packages have all of the program's files in a single file, while a package manager reads, extracts, and performs any set-up operations that are needed (such as installing dependencies first). Not everyone agrees with where the files should go, which is why each Linux distribution does things differently. (The package manager and the choice of what packages to include are probably the biggest things that set one distribution apart from another.) This disagreement over locations and formats resulted in the myriad of distributions we see today. It has also created a lot of extra work.

When an upstream project—such as VLC, for example—pushes a release, the developer has to determine how it wants to distribute its binaries. If a developer releases a .deb for Debian and Ubuntu, someone else has to maintain the packages for Fedora, Arch, and others. There is an army of package maintainers who spend their days and nights repackaging software to fit neatly into a distribution's structure.

Two new packaging formats are going to duke it out in 2017.

> Package maintainers spend their days and nights repackaging software to fit into a distribution's structure.

That's the problem Flatpak and Snap want to solve, and they do it by siloing applications in their own little bubbles of reality. The idea of sandboxing is nothing new, and isn't too far off from Docker, which is built to containerize programs for servers. Flatpak and Snaps distribute runtimes for their programs to run on. These runtimes allow a program to be written for a particular version of a library, so that when the system is updated, the program still has access to the library it was designed for. This makes Snaps and Flatpak all-in-one solutions for desktop software distribution. Which is why it's going to be interesting to see which format wins.

Right now, Ubuntu has more software available as Snaps, but people are concerned about Canonical's Contributor License Agreement that developers and contributors have to sign. Fedora claims that Flatpaks are more open, and have better security (as long as the user is running Wayland instead of X). The problem is, there isn't a lot of software released as Flatpaks yet, with the notable exception of programs that come with the GNOME desktop environment (such as Evolution and Gedit). To add to the fun, Ubuntu is now using GNOME's Software application (which has built-in support for Flatpak) instead of its own Software Center application.

The sandboxing of desktop apps has a lot of potential for security and distribution, but first the community has to agree on a universal standard, or this exercise ends where it began: with different formats everywhere, and a lot of wasted time on repacking packages.

Alex Campbell is a Linux geek who enjoys learning about computer security.

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THE LIST

MAXIMUM PC's TOP 7 MICE

7

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6

MAD CATZ RAT 8

($100) The mouse with as many customization options as building your own system, the Mad Catz RAT 8 is stunning.

5

MIONIX NAOS QG

($130) With clever sensors that can tell you if you're dying in the middle of a pixel firefight, the Naos QG aims a few punches at the peripheral industry.

4

LOGITECH G900 CHAOS SPECTRUM

($123) Combine the brilliance of the Proteus with wireless tech and a new ambidextrous design, and you're left with the Chaos Spectrum. If only it weren't so pricey....

3

CORSAIR M65 PRO

($60) The combination of a soft-touch finish, sand-blasted plastic and aluminum chassis, and dependable lighting makes the M65 Pro one of the most enjoyable mice to use.

2

LOGITECH PROTEUS SPECTRUM

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1

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HEAD TO

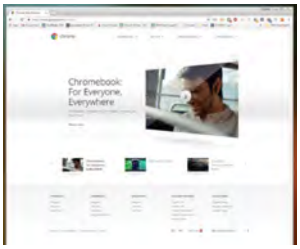
BY **MATT HANSON**

Firefox vs. Chrome vs. Edge

Most of us use the humble web browser more than any other program. These ubiquitous apps act as portals to the Internet, and because we use them daily, we want them to be reliable and easy to use, as well as secure. By far the most popular browsers on Windows are Chrome (with 57.1 percent of the market in November 2016) and Firefox (with 11.1 percent). Microsoft's Internet Explorer has fallen from grace, but the software giant is pushing its new browser, Edge, in Windows 10, in a bid to gain its lost market share. There are other browsers, such as Opera, but we're looking at the three major players, to see which is best.

Firefox
Browse Freely
Keep up with

Firefox is a stalwart web browser that offers plenty of cutting-edge features.



Chrome is the most popular web browser on the Internet— but is its success warranted?

Introducing Microsoft Edge

Edge is the newbie in this test. Has Microsoft learnt from Internet Explorer's sins?

ROUND 1

Performance

We want a number of things in a web browser. First, it needs to be able to display even the most graphic-heavy websites quickly, while showing any embedded media without problems. It also needs to remain fast and responsive, no matter how many windows or tabs you have open. Chrome is a notorious memory-gobbler, especially when you have a number of extensions installed, and Firefox can also be a victim of its own add-ons. Edge's current lack of extensions works to its advantage, giving a more sprightly feel. However, in the Kraken JavaScript 1.1 benchmark, which records the speed of various JavaScript test cases, Chrome 55 came out on top, taking 1,129ms to complete the tests, compared with Edge's 1,180ms and Firefox 46's 1,376ms. However, Edge came out top in the JetStream 1.1 and Octane 2.0 benchmarks, showing that Microsoft's focus on optimizing Edge has paid off.

**Winner:
Edge**

ROUND 2

Usability

Installing Chrome or Firefox is simple—head to their websites, and click "Download." Edge has an advantage, as it is preinstalled in Win 10. The interface of all three is very similar. You have an address bar at the top, and they all double as a search box, with Chrome and Firefox defaulting to Google, while Edge uses the less popular Bing. Firefox also includes a search box, which feels redundant. Firefox drops the forward button, yet maintains the back button, while Chrome and Edge feature both forward and back buttons. The interfaces of Firefox and Chrome can be altered with extensions and themes, unlike Edge. All three have a cloud sync feature that lets you synchronize your bookmarks, history, and passwords over many devices. However, Edge is only available on Windows 10 machines, while Firefox and Chrome are available over a wide range of platforms and devices.

**Winner:
Tie between Chrome
and Firefox**

ROUND 3

Extensions

Extensions (aka add-ons) can expand the functionality of your browser, giving you quick access to your most-used services (such as Google Drive), or improving your experience (such as ad-blockers that make sites load faster, while ditching ads). Chrome's popularity gives it a huge advantage, as pretty much all add-on developers build an extension for Chrome before other browsers. Google apps and services are very well served in Chrome, and the add-on store—plus the installation process—is straightforward. Firefox also has a robust add-on store that makes it easy to find and install the add-ons you need. Firefox's popularity means that most major add-ons are available. Edge is the least flexible, as it has only recently started to support extensions. Unlike Firefox or Chrome, it's not open source, so we can't see Edge add-ons taking off in the same way as those of its competitors.

**Winner:
Chrome**

HEAD

ROUND 4

Standards Support

You don't want to come across a site that uses a standard or language that your browser doesn't support. Chrome has been built from the ground up to support as many standards as possible, and it shows. In particular, Chrome is known for its HTML5 compliance, and in the HTML5 compliance benchmark it scored 502—with 555 being perfect. Firefox scored 466, with Edge scoring 453. Chrome is based on the WebKit engine, which is renowned for passing all the Acid3 web standards tests (try your browser at http://acid3.acidtests.org). Firefox also scored 100/100 for Acid3, as did Edge. This might not be an exciting result, but it means that no matter which of the three browsers you use, you won't find their standards support lacking. A shout-out must go to Chrome's WebKit engine, while Microsoft has also been making moves to ensure that Edge's support is cutting edge.

Winner:
Tie

ROUND 5

Resource Use

Resource use focuses on the amount of RAM and other resources that a browser commands. If a browser is too RAM-hungry, it can slow down your entire computer, even when the browser's not in use. Chrome is notorious for loading processes. You can see this in Windows Task Manager. We opened 10 pages in Chrome, which launched 16 processes, and gobbled up 512MB of RAM. On less powerful devices, you'll see a real drop in performance. CPU usage when on sites with animated images peaked at 80 percent. Firefox was more restrained, with three loaded processes, a memory usage of 270MB, and a CPU peak of 62 percent. Edge brought up 12 processes, using 420MB of memory, with CPU usage peaking at 40 percent. No web browser excelled here, though Firefox was the most efficient. However, some lesser-known browsers pride themselves on keeping resource usage low.

Winner:
Firefox

ROUND 6

Security

It's a sad fact of life that if you're on the Internet, at some point you're likely to be subjected to malicious code, so security and privacy features of web browsers are welcome additions. Chrome and Firefox both use the Google Safe Browsing API, which identifies potentially malicious sites, and warns you about accessing them. Both Firefox and Chrome also have a number of add-ons from security companies such as Kaspersky, which can add another layer of protection when you're surfing. Chrome can also scan files you download, and warn you if you have any infected files. Edge isn't as robust, as it doesn't feature those add-ons, though it does use the SmartScreen Filter from Microsoft, which can help identify potentially dangerous websites or files. Edge has also ditched support for third-party toolbars, which were big security threats in its predecessor, Internet Explorer.

Winner:
Chrome

And the Winner Is...

It appears that Chrome's popularity has a reason, because in our tests, **Chrome** came out on top—or near the top—in almost every aspect. This is a robust and feature-rich web browser that makes surfing the Internet a joy, thanks to its speed, standards support, cloud sync features, and huge selection of extensions. The only area it falters in is resource use—this can be a demanding browser, especially if you add loads of extensions and open up tons of tabs when browsing. However, Firefox is still a very compelling alternative, and if you love Mozilla's web browser, we recommend sticking with it, because you're not missing out on much. Finally, Edge has a lot of improvements over Internet Explorer (not particularly difficult), and while this browser is still a relative newcomer on the block, it shows potential, especially since the Windows 10 Anniversary Update. ⏻

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Sneaky Software
> Microsoft Bugs
> Random Shutdowns

Sneaky Software

Hi Doctor. I downloaded and installed Adobe Acrobat Reader DC, and was shocked to see two other applications, McAfee Security Scan Plus and True Key by Intel Security, being installed at the same time, with no option to cancel. As I recall, there was no checkbox dialog asking if I wanted those apps prior to loading Adobe's software on to my PC.

Do you have any idea what might have prompted this uninvited intrusion? Are other program downloads using the same forced install for software we didn't ask for? I was able to uninstall True Key and disable McAfee in "Task Manager → Startup," however, I would have preferred Adobe not to push them through on the back of its Reader. **–Phil Saunders**

THE DOCTOR RESPONDS: Bundled software is the bane of an enthusiast's existence, and most go to great lengths to keep bloatware from slowing their systems down. The Doc visited Adobe's site using Firefox and Windows 10 to replicate your issue, Phil, and found that Security Scan Plus and True Key were optional offers, selected by default, before clicking the "Install now" button. He then visited using Chrome, and discovered that only True Key was listed. Finally, he tried the same link in Microsoft Edge, and was given an offer to download Chrome.

An Adobe representative on the company's forums confirms that the installer displays these offers based on detected OS and browser. For those who see no offer and end up with software they don't want, it's possible that an installed ad-blocker is preventing the checkboxes from showing up, leaving you with the default selection. Adobe says the choices also don't show up when the optional software is already installed. Now, that's not to excuse Adobe for creating a situation where you end up with unwanted bloat unless specifying otherwise. At the very least, those boxes should be unchecked to start. The Doc found complaints to Adobe dating back five years. You would hope someone over there is listening.

Acer's Predator Z35 is a solid ultra-wide option for gamers with GeForce cards and a proclivity for high refresh rates.

Squashing Bugs

Doc, I am a long-time reader, and like to open up your column as soon as I receive my issue of the magazine. My problem is that ever since I upgraded to Windows 10, whenever I click on a URL in an email (I use Outlook 2007), I get a dialog box asking me to choose how to open it. The options are IE and Edge, or get an app from the Store. I have IE set as default, but keep getting asked even after checking "Always use this app." Any ideas? **–Jim Moraseski**

THE DOCTOR RESPONDS: This is a known issue that applies to Windows 10, Internet Explorer 11 set as default browser, and Outlook 2007/2010 installed. According to Microsoft, it occurs because certain information is missing from your Registry. The company says it's looking into it, but last reviewed the Knowledge Base entry more than a year ago.

Fortunately, there is a relatively simple resolution. The problem is detailed at https://support.microsoft.com/en-us/kb/3094186, and you have two options: download Microsoft's easy-fix wizard and follow its prompts, or scroll to "Let me fix it myself," and add the missing Registry entries.

The Perfect Monitor

Hey Doc, I'm really hoping you can help me! I own a BenQ XL2720Z Black 27-inch 144Hz gaming monitor. It's great for first-person shooters, thanks to that 144Hz refresh rate and 1ms response time. I've also bought an Nvidia Titan X (Pascal).

But what I really want is a nice ultra-wide monitor. My

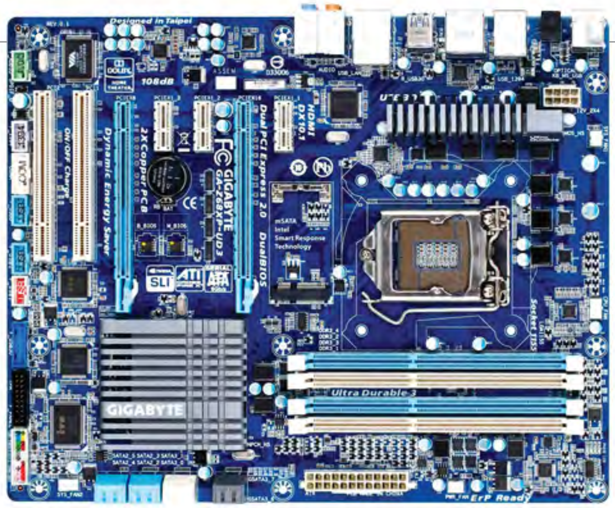
↘ submit your questions to: doctor@maximumpc.com problem is that the current crop of ultra-wides is missing both 144Hz and 1ms grey-to-grey response times, which I need for competitive FPS gaming. I recently saw LG's 38UC99 and 34UC79G-B, and want to know if either would satisfy me, or should I continue waiting? I don't want to take a step back on response rates just to get ultra-wide resolution. **–Erik Figler**

THE DOCTOR RESPONDS: While the Doc hasn't had a chance to use either LG display, he can tell you that neither satisfies your requirements exactly.

The 34UC79-G seems to come closest with its 144Hz refresh and 1ms Motion Blur Reduction feature. However, its real response time is actually 5ms GTG. The 1ms claim comes from a strobed backlight feature used by LG to minimize motion blur at the expense of peak brightness. Turning it on disables AMD's FreeSync technology, but that's not a deal-breaker, given your Titan X. A $700 price tag does sound steep for a resolution of 2560x1080. If you're enamored with a 21:9 aspect ratio, though, the 34-inch curved monitor strikes an imposing figure.

At around $1,600, the 38UC99 is even more deluxe. Its 3840x1600 resolution should be serviceable by Nvidia's Titan X in most games. However, a peak refresh rate of 75Hz falls well under your target. And that screen similarly has a 5ms GTG response rate. Fortunately, it also includes LG's 1ms Blur Reduction, if you don't mind a strobed backlight at 75Hz.

Acer has some interesting alternatives with G-Sync support, rather than FreeSync, which is more apropos to your graphics card. The Predator X34 uses a 34-inch IPS panel with a 3440x1440 resolution, offers 4ms response time, and a 100Hz overclocked refresh rate. The Predator Z35 is even larger at 35 inches, but uses a curved screen with a 2560x1080 resolution, so lacks the X34's pixel density. A VA panel might not be the best for fast action. You'd probably love the 144Hz refresh rate, though, even more so as it overclocks up to 200Hz.



The Z68P-UD3 motherboard launched alongside Intel's Sandy Bridge, but was updated to support Ivy Bridge-based CPUs, too.

Windows Mail Woes

Doc, I have been a *Maximum PC* reader for years and love the mag. A quick question: I'm using Windows Mail 2012 to manage email messages from three accounts, and was running Windows 7 Ultimate until I upgraded to Windows 10 Professional. My problem was the same under both versions of Windows. I save a lot of emails. Some are important and need to be referenced at a later date. To keep them organized, I use many different folders within the app. As an example, I might have a folder called "Maximum PC" with 10 messages. But later, when I try to access that folder to look at saved emails, all 10 appear the same. I can scroll through the messages, but their content is identical.

I've searched for answers, but there is no cure as of yet. Every folder has been scanned by Norton's Internet Security, and nothing comes up. Not all of my folders exhibit this issue, but many do. I noticed that Win 10's built-in email app looks pretty good. Might that be an option? **–Randy Hardman**

THE DOCTOR RESPONDS: The Doc believes you may be better off finding an alternative to Windows Mail 2012 than trying to diagnose its behavior. Microsoft made some changes to its service early in 2016 that required anyone with an @outlook.com, @hotmail.com, @live.com, or @msn.com address to patch Windows Mail. This update caused other issues, though, prompting the company to suggest moving to newer software, such as Windows 10's Mail app.

If you value integration with services such as Skype, PayPal, and Uber, or want your messages synchronized across devices and accessible through a common interface, consider creating an account on Outlook.com. There's always the ubiquitous Gmail, too.

Random Shutdowns

Hello Doc, I love the mag and your advice, so I hope you can help. I have a pretty awesome gaming rig and I'm fairly savvy, but this issue has me stumped. My system consists of a Gigabyte Z68XP-UD3, Core i7-3770K with an Intel closed-loop liquid cooler, 16GB of G.Skill DDR3-1866, a Thermaltake Toughpower 850W 80 PLUS Gold PSU, a Gigabyte GeForce GTX 980 Ti, a 128GB SATA-based SSD, two 2TB storage drives, one of which is complemented by a 64GB SSD cache, all in a Corsair 760T. I'm giving you as much detail as possible to help with troubleshooting.

Intermittently, the system turns itself off without warning. Most often, it's while playing a game, but I've also had it happen browsing the web and sitting on the Windows desktop. It's so random that I cannot figure out where the problem lies.

I've looked into Windows' reliability history, which shows the PC was simply shut down incorrectly. I also changed the Startup and Recovery setting where, on system failure, the PC should not automatically shut down. I was hoping I'd get a blue screen with an error message. The system still just turns off randomly. I also tried using the second PCIe slot for my GPU, running with peripherals removed, and removing RAM, to no avail. I haven't yet tried integrated graphics, but if you think my GPU is a suspect, I will. Most of all, I'd like to know that if I upgrade my motherboard, RAM, and CPU, this problem will go away. I don't think the PSU is my culprit; it's only a couple of years old, Gold-rated, and high quality. I was, however, running two Radeon R9 290s on it, which may have stressed its output limits. I'm most suspicious of the mobo as it's the oldest component and fairly value-oriented. **–Adrian Sultana**

THE DOCTOR RESPONDS: As you know, troubleshooting is often a process of elimination, and it sounds like you've covered several possible causes. But heat is the first malady that comes to mind when the Doc hears about random shutdowns, which happen to be most prevalent in demanding applications such as games.

Have you checked the closed-loop cooler's fan to make sure it's still blowing? Is the radiator clogged with dust? Might the thermal interface material on your CPU be due for a fresh application? How about airflow in your chassis? Download Core Temp or Intel's Extreme Tuning Utility—both help monitor a CPU's health.

If heat isn't an issue, how about a BIOS update? You're using a Z68-based mobo and an Ivy Bridge CPU. That Platform Controller Hub first launched with Intel's second-gen Core CPUs; support for your Core i7-3770K was added via firmware. Make sure you have the latest version. Gigabyte published a beta UEFI in 2013, which could iron out compatibility issues with modern storage and graphics devices.

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EVERY ISSUE, we're set new challenges. Whether it's via our executive editor, our editor-in-chief, or the management bods who want those big headlines on the front cover, we're thrown into the belly of the beast with a new conundrum to tackle. And each issue, those challenges get more extreme. This time, we were sat down and told: "$300— that's your budget. We want a 250GB SSD, and 8GB of memory. Do it!"

And so here we are. Maximum performance at the absolute minimum budget. A base system that can operate efficiently and quickly, yet is fully capable of being upgraded to compete with some of the most prestigious mid-range gaming or office PCs out there. But who are we if not suckers for punishment? Instead of one single $300 bunker-busting bomb, we decided to pit those two old processing dogs against each other—Intel versus AMD—in the ultimate budget build-off, to finally settle the debate once and for all (or at least until Ryzen and Kaby fully launch, and we have a whole plethora of new parts to consider).

AMD INGREDIENTS

PART		PRICE
CPU	AMD A8-7600 3.1GHz Quad-Core	$69
Mobo	Asus A68HM-K MicroATX	$47
RAM	8GB (2x 4GB) Patriot Viper 3 DDR3-1600	$46
SSD	Kingston SSDNow UV400 240GB 2.5-inch SSD	$68
Case	Fractal Design Core 1100 MicroATX	$35
PSU	EVGA 450B 450W 80+ Bronze Certified	$37
TOTAL		$302

INTEL INGREDIENTS

PART		PRICE
CPU	Intel Pentium G4400 3.3GHz Dual-Core	$55
Mobo	Gigabyte GA-H110M-S2H MicroATX	$63
RAM	8GB (2x 4GB) HyperX Fury Black DDR4-2400	$52
SSD	Crucial MX300 275GB 2.5-inch SSD	$81
Case	NZXT Source 210 ATX	$40
PSU	Corsair CX500 500W 80+ Bronze Certified	$50
TOTAL		$341

Prices correct at the time of going to press.

$300 BUILD IT CHALLENGE

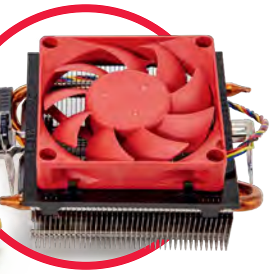
Two builds, two processors, two teams, and a $300 budget

BY ZAK STOREY

INTEL BUILD

AMD BUILD

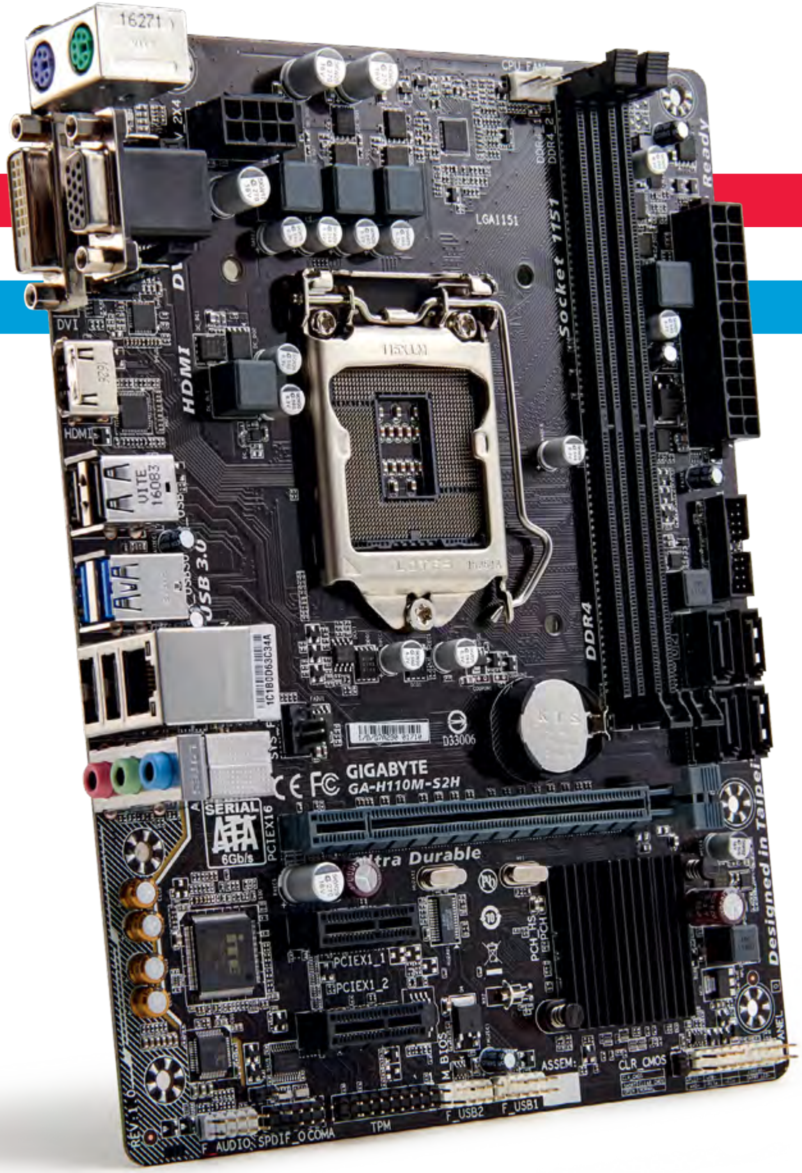
AMD A8-7600 Series
AD845XACI43KA
SA 1543SUS
9FS7961K50352
AMD © 2015 AMD
DIFFUSED IN GERMANY
MADE IN CHINA



AMD CPU

AMD A8-7600 3.1GHZ QUAD-CORE $69

Intriguingly, we flipped the boat on this one and went with a slightly more expensive AMD chip. Because we managed to neatly make some savings elsewhere in the build, we could splurge a touch more, so opted to go for the now-slightly-ageing quad-core A8-7600. Although AMD does have the X4 845 at a slightly cheaper price point, the lack of integrated graphics is a real deal breaker. We'll be honest: We pinched this cooler from an A10-7670K, but rest assured, both this and the Intel chip do come with stock coolers as pictured, so there's no need to worry about your chip overheating.


GIGABYTE
GA-H110M-S2H
Ultra Durable
Socket 1151
DDR4
HDMI
USB 3.0
DVI
LGA1151
Designed in Taipei

INTEL MOTHERBOARD

GIGABYTE GA-H110M-S2H $63

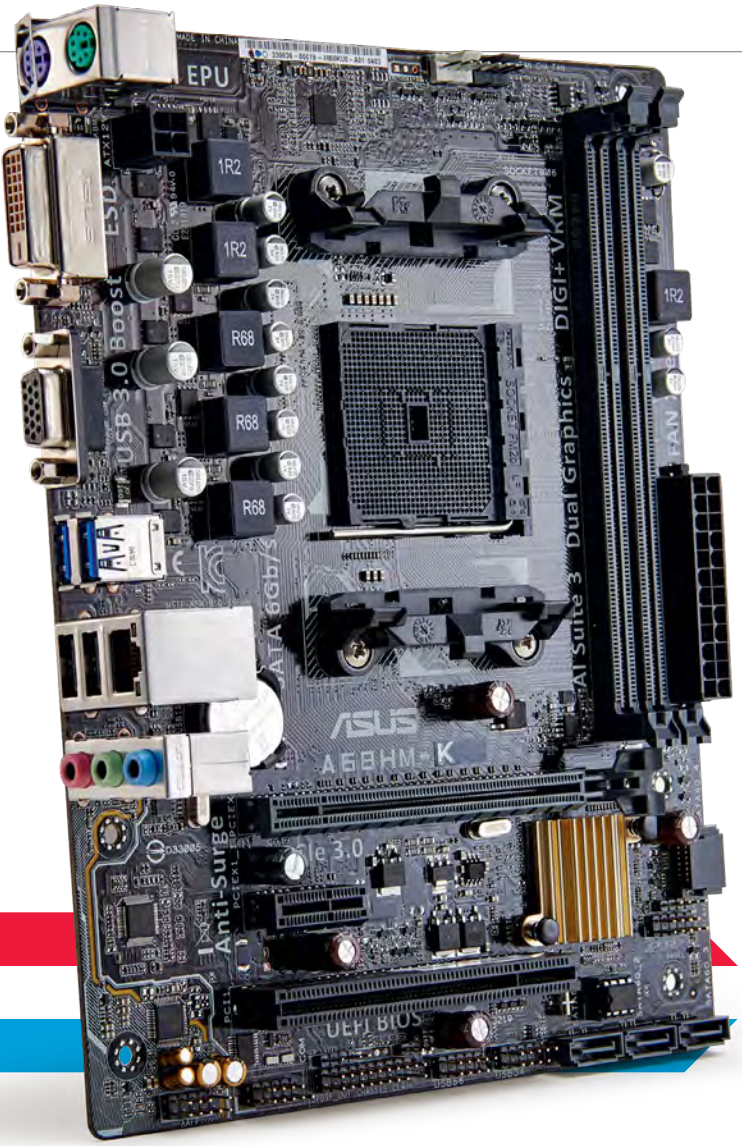
Gigabyte's a fond favorite of ours, providing good-quality motherboards, jam-packed with features at a respectable price. Well, at least once you hit the $100 mark, of course. To even attempt to reach our allocated Intel budget, we had to settle for the H110 chipset. What this meant was a microATX form factor motherboard, with USB 3.0, a single PCIe 3.0 slot, no M.2 support, semi-acceptable audio (fortunately), four SATA 3 ports, and an HDMI connection as a backup. Not exactly perfect, but not too shabby either.

AMD MOTHERBOARD

ASUS A68HM-K

$47

More budget offerings—this time from another favorite: Asus. The A68HM-K is a microATX budget mobo, primed with an FM2+ socket ready for any of the Kaveri line of processors. With relatively slim pickings on board, you net access to four SATA 3 slots, two USB 2.0 headers, two PWM fan headers, and a very limited set of rear I/O. It's almost plain sailing if it weren't for the lack of HDMI connectors. Time and again, we've slated AMD for being too many chipsets behind its rival, and the A68HM-K makes that painfully obvious. However, budget is budget, and you can still equip this with dependable SSD storage, 16GB of DDR3, and any of the latest and greatest GPUs.



INTEL CPU

INTEL PENTIUM G4400 3.3GHZ DUAL-CORE

$55

The old adage states that if you're on a budget, you'll get better value per buck by hopping over to AMD. Although that has become somewhat diluted in recent years, it is still true in essence. So, our choice of Intel's Pentium G4400 is on the bottom rung of Team Blue's processors. But, featuring two 14nm cores, Intel Iris HD 530 graphics, and 3MB of L3 cache, it touts support for Intel's latest and greatest chipsets, alongside some phenomenally beefy single-core performance for the price.

INTEL BUILD

AMD BUILD

PATRIOT
VIPER
PATRIOT
VIPER

AMD MEMORY

8GB (2x 4GB) PATRIOT VIPER 3 DDR3-1600 $46

DDR3 may not be the latest memory technology, but it's still more than sufficient when it comes to normal day-to-day operations and even gaming. With slightly higher latencies, lower capacities, and increased power draw, you're not losing out on much in contrast to DDR4. We chose 8GB of Patriot memory here, because it's the absolute minimum amount we recommend for any new build, and Patriot is a brand that we've come to trust to provide good-quality components, along with a solid warranty. The only downside is that, in the long run, it's not going to be as easy to upgrade with as the DDR4 kit featured in the Intel build, because all the latest platforms are finally shifting across to the new standard.

INTEL SSD

CRUCIAL MX300 275GB SSD $81

crucial
by Micron
2.5-inch SOLID STATE DRIVE

This is arguably one of the few places you could shave money off those budgets. Running a system off a single 120GB SSD has been the norm for quite a few years, but as both these configurations lack any additional storage in the form of a traditional spinning hard drive, we decided that bumping up the SSD with a chunk of extra gigabytes would waylay some of those storage woes later on down the line. Crucial's MX300 series is a solid-performing, well-priced range of SSDs, built by the respectable foundries of Intel's partner company, Micron. With reads and writes well above the 500MB/s mark, this is well worth the cash.

AMD SSD

KINGSTON SSDNOW UV400 240GB

$68

Another circa-250GB SSD hitting the block here. This time, it's a slightly smaller offering than the Crucial MX300, but no less of a performer. This budget-busting solid-state drive performs well into the 500GB/s range as standard, and comes at the astronomically low price of $68. Although that may look cheaper than the Crucial MX300, you have to bear in mind that you do lose an additional 35GB, so the price of the two drives is almost identical when it comes to dollar per gigabyte. You could always get away with a 120GB SSD instead, to drop the overheads, but we feel that double that capacity will keep you happy long-term, until you decide to upgrade at a future date.

INTEL MEMORY

INTEL BUILD

8GB (2x 4GB) HYPERX FURY BLACK DDR4-2400

$52

Eight gigabytes is widely regarded as the absolute minimum amount of memory you should be looking at when building any new system on a modern platform. DDR4 is the go-to for any new Skylake-based system, and, surprisingly, 2,400MT/s is actually just as cheap as the 2,133MT/s kit. In reality, Gigabyte's GA-H110M-S2H can only support DDR4 up to 2,133MT/s, so we would be running this kit at a slightly lower frequency than its advertized spec—but, honestly, you wouldn't be able to tell the difference, and it does provide you with some future-proofing if you want to swap out to another motherboard later down the line.

AMD BUILD

AMD PSU

EVGA 450B 450W 80+ BRONZE CERTIFIED $37

EVGA has constantly impressed us ever since it first launched its range of power supplies, because it provides some fantastic value options, all the way up to the most premium of Platinum-punching PSUs. The EVGA 450B is a 450W Bronze-certified power supply, and is more than capable of supporting this system, even if we wanted to include an additional GPU later down the line. It's a non-modular, ATX-sized variant, granted, but for the price, plus the included warranty, and EVGA's legendary reliability, this a is no-brainer for anyone on a tight budget.

INTEL CASE

NZXT SOURCE 210 ATX CHASSIS $40

This is the ATX budget case of choice, as far as we're concerned. For $40, you net yourself a full-sized midi tower capable of housing an ATX motherboard, multiple fans to support cooling, 5.25-inch drives, and a plethora of 3.5-inch hard drives. Unfortunately, there's no easy way of mounting 2.5-inch SSDs, but with a bit of double-sided sticky tape, you can hide them or mount them on the floor or side of the chassis without worry. We're using the Elite version of the S210 here (as NZXT doesn't sample cases any lower than that), but the only difference between the two are the included fan, and the tool-less 5.25-inch and 3.5-inch bays.

AMD CASE

FRACTAL DESIGN CORE 1100 MICROATX CHASSIS $35

It's not the fanciest chassis out there, but for the price, it's hard to find much better. Fractal's Core 1100 offers a simple yet somewhat antiquated design, ideal for anyone looking to build their first system. Only supporting up to microATX motherboards, it does limit your upgrade potential, and the lack of cooling support beyond the front 120mm fan is a little unnerving, but you can still build a snazzy little system inside, without taking a huge hit on performance. The top-mounted PSU is a little old-school, but it does help improve internal airflow inside the chassis by shifting more air out of the rear, and if cooling becomes a worry, you can always mount a 120mm fan on the side panel.

fractal design

INTEL PSU

INTEL BUILD

CORSAIR CX500 500W 80+ BRONZE CERTIFIED $50

We'll be honest—you could easily get away with using the EVGA 450B PSU we suggested for the AMD system on this config. In fact, even if you added an additional hard drive and modern GPU, neither system would be pulling more than 250W from the wall under load. However, we wanted to showcase two separate power supplies for this feature. There's very little difference between the two, though, short of manufacturer—however, brand loyalty, in this case, does cost you. Generally speaking, though, if you do plan on upgrading, we would suggest you invest in a Corsair RM series power supply, to reduce cable clutter with a relatively cheap modular PSU.

AMD'S BONKERS BUDGET BOX $300 PRICE TAG ACHIEVED

OUR AMD BUILD looks quite dainty compared to Intel's behemoth. The microATX Core 1100 offers little room for cable management, though. We tucked a lot of the cables inside the 5.25-inch bay, while sticking the Kingston SSD to its side with double-sided tape.

We contemplated using AMD's more price-aggressive and newer X4 845 quad-core CPU, but it lacked integrated graphics. So we opted for the three-year-old A8-7600. Still featuring a quad-core processor clocking up to 3.8GHz, it should be a meaty choice. However, we had trouble getting it to clock any higher than 1.9GHz with 50 percent utilization in most of our CPU-intensive benchmarks. It took several reinstalls of the chipset and some BIOS tinkering to get it to hit the mark, and even then consistency in other benchmarks failed on several occasions.

We were impressed with how well it ran in-game, though. Even with that ageing APU architecture, frame rates in *Rise of the Tomb Raider* (on low settings at 728p) were impressively comfortable, nearing 30fps, demolishing Intel's Iris HD 530 graphics. All of which bodes well for the low-end offerings coming up with Ryzen, too.

Simply buying a better graphics card and throwing a larger hard drive at it may not be the best upgrade choice. AMD's single-core performance has always held it back and can lead to bottlenecks. It's pricier, but for gaming we recommend investing in an A10-7890K for better single-core performance, on top of the 500GB HDD and GPU of your choice, bumping the upgrade price up to $300. If it's a home theater you're after, a low-end GPU might do you more favors, with an RX 460 2GB and 1TB HDD setting you back $140.

AMD BENCHMARKS

Cinebench R15 Single-Core	80
Cinebench R15 Multi-Core	240
AIDA64 Memory Latency	114.5ns
SiSoft Sandra Memory Bandwidth	10.5GB/s
CrystalDisk Sequential Read	553MB/s
CrystalDisk Sequential Write	485MB/s
PCMark 8 Home Accelerated	2,401
PCMark 8 Work Accelerated	3,522
Rise of the Tomb Raider @ 768p	26fps

Rise of the Tomb Raider was run at 1366x768 on integrated graphics at the lowest possible settings. Average frames recorded in the integrated benchmark.

INTEL'S STEAL OF A SYSTEM COULD HAVE BEEN CHEAPER

WHEN IT CAME to building this PC, the most important decisions revolved around how best to attempt the cable management, and what limited cooling you could achieve with the included fans.

Overall setup was a cakewalk. A quick installation of Gigabyte's chipset and motherboard drivers gave us a rig that ran smoothly with little issue. Getting the games up and running was trickier, with most erroring on first attempt. We found we had to directly install the VGA driver from Gigabyte's site, something we usually leave to Windows Update, then force a DirectX install on top of that.

Choosing which game to benchmark was tricky, as we didn't meet the minimum spec for a lot of them. *Metro 2033* was our first attempt, but upon successive crashes, we caved in and opted for an old favorite, *Rise of the Tomb Raider* (at the lowest settings and 1366x768). Impressively, on integrated graphics we managed an almost watchable 11fps in-game. Although that doesn't sound like much, you could play some of the older classics at lower resolutions without too much of an issue.

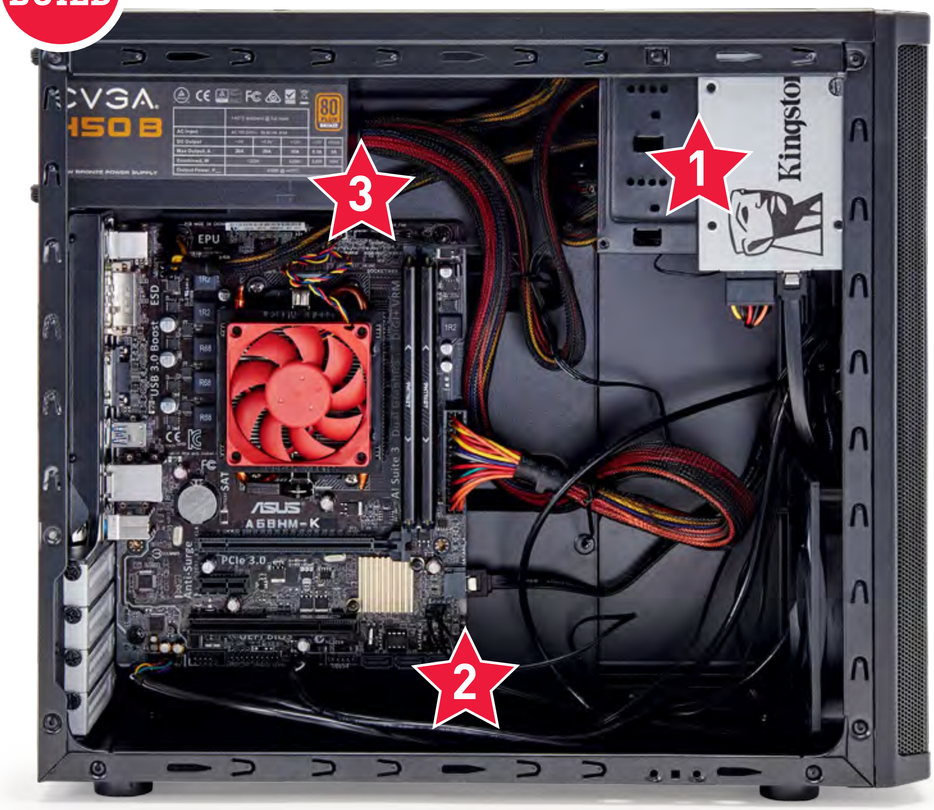
In its current state, the Intel machine breaks our $300 budget by 41 bucks. It would've been possible to drop that price simply by shrinking the SSD and using a cheaper EVGA PSU, but we advise sticking with a named brand in case of power surges. That aside, for day-to-day office use, it's exceptionally good value for money. If you were looking at upgrading in the long term, for gaming we suggest grabbing a 500GB HDD and potentially a GTX 1050 or RX 470, for around $143 in total. For a home theater machine, simply grab yourself a 1TB HDD for around $50, and you'd be on to a winner.

INTEL BENCHMARKS

Cinebench R15 Single-Core	137
Cinebench R15 Multi-Core	271
AIDA64 Memory Latency	62.6ns
SiSoft Sandra Memory Bandwidth	22.6GB/s
CrystalDisk Sequential Read	531MB/s
CrystalDisk Sequential Write	503MB/s
PCMark 8 Home Accelerated	2,952
PCMark 8 Work Accelerated	4,130
Rise of the Tomb Raider @ 768p	11fps

Rise of the Tomb Raider was run at 1366x768 on integrated graphics at the lowest possible settings. Average frames recorded in the integrated benchmark.

AMD BUILD



1 SSD MOUNTING

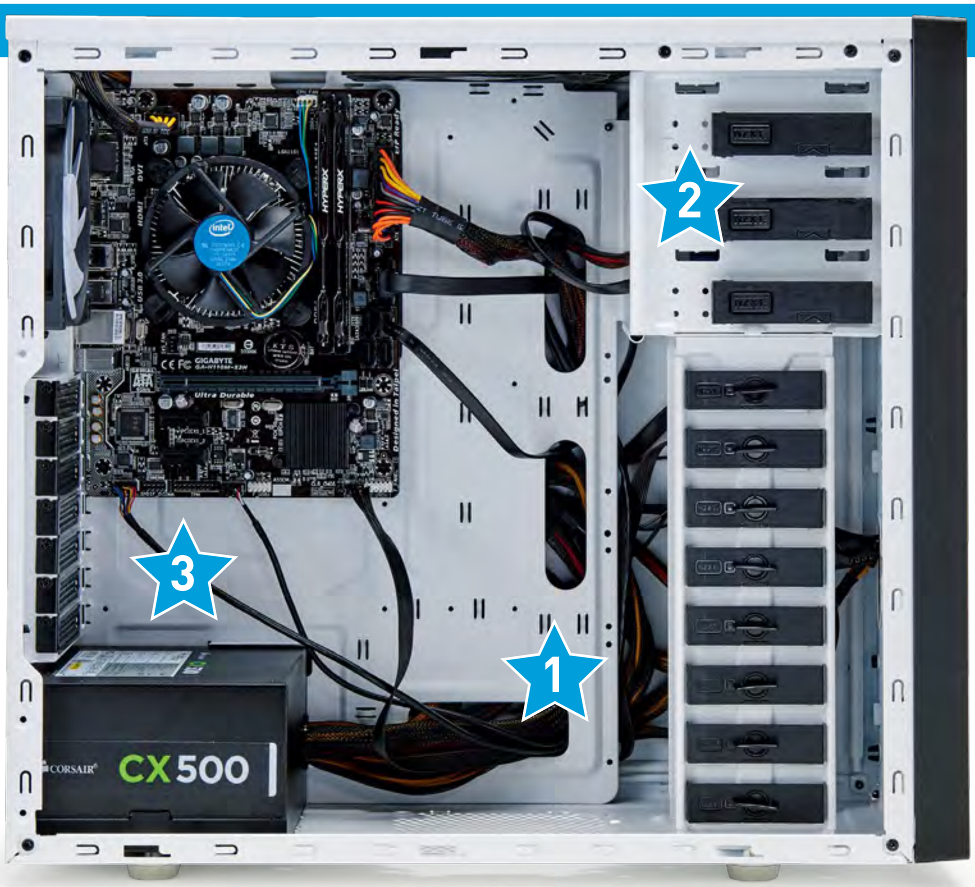
Along with some double-sided sticky tape trickery, we've also threaded the SATA power through the bottom of the 5.25-inch bay to keep it tidier.

2 FRONT I/O ANNOYANCE

Due to a lack of any cable routing options, and a front 80mm intake fan, cable-tying the front I/O cables is a necessity.

3 TOP-MOUNTED PSU

It's a little old-school, but the top-mounted power supply isn't too much of an issue—however, we would suggest installing it before anything else.



1 CABLE MANAGEMENT

Fortunately, the Source 210 comes with plenty of cable management room in the rear, so we managed to route the vast majority of the cables out of sight.

2 HIDDEN SSD

We actually managed to tuck the Crucial MX300 right out of the way in the 5.25-inch drive bay, keeping it out of sight, but easily accessible.

3 FRONT I/O CONNECTORS

The only problem with having a microATX board in a full-sized ATX tower is that you end up stretching the front I/O connectors all the way up.

INTEL BUILD

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- 512GB SanDisk X400 M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives or 2 M.2 PCIe SSD Drives capable
- Hardware Raid 0,1 Function capable
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intel
CORE™ i7
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- Opt. NVIDIA® GeForce™ GTX 1060 or 1080 GPU
- 16GB Dual Channel DDR4-2400MHz Memory
- 256GB SanDisk X400 M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives or 2 M.2 PCIe SSD Drives capable
- Hardware Raid 0,1 Function capable
- Full sized Keyboard with color LED backlight
- Killer DoubleShot™ Pro (Killer E2400 LAN + Killer Dual Band Wireless-AC 1535) with Smart Teaming
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- Opt. 15.6" FHD, 120Hz 5ms Matte Display with G-SYNC
- 6GB DDR5 NVIDIA® GeForce™ GTX 1060 GPU
- Optional NVIDIA® GeForce™ GTX 1070 GPU
- 16GB Dual Channel DDR4-2400MHz Memory
- 256GB SanDisk X400 M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives or 2 M.2 PCIe SSD Drives capable
- Hardware Raid 0,1 Function capable
- Full sized Keyboard with color LED backlight
- Killer DoubleShot™ Pro (Killer E2400 LAN + Killer Dual Band Wireless-AC 1535) with Smart Teaming
- USB 3.1 / Thunderbolt Gen3 Combo Port
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- 16GB Dual Channel DDR4-2400MHz Memory
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- 16GB Dual Channel DDR4-2400MHz Memory
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- Hardware Raid 0,1 Function capable with SATA Interface
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- Full sized Keyboard with color LED backlight
- Intel® Dual Band Wireless-AC 3165 + Bluetooth
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- 6GB DDR5 NVIDIA® GeForce™ GTX 1060 GPU
- 16GB Dual Channel DDR4-2400MHz Memory
- 256GB SanDisk X400 M.2 SSD + 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives Capable with Raid 0,1 Function
- Full sized Keyboard with color LED backlight
- Intel® Dual Band Wireless-AC 8260 + Bluetooth
- Built-in 2.0M FHD Camera & Fingerprint Reader
- Sound Blaster® X-Fi™ MB5 Sound System
- Slim design with only 1.18 inch thin

NP8155 Notebook
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- 7th Generation Intel® Core™ i7-7700HQ Processor (6MB Smart Cache, 2.81GHz)
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- 15.6" Full HD IPS Matte Display (1920x1080)
- 3GB DDR5 NVIDIA® GeForce™ GTX 1060 GPU
- 8GB DDR4-2400MHz Memory
- 1TB 7200RPM Hard Drive
- 2 Hard Drives + 2 M.2 SATA SSD Drives Capable with Raid 0,1 Function
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FORENSICALLY EXAMINE YOUR PC'S PROCESSES

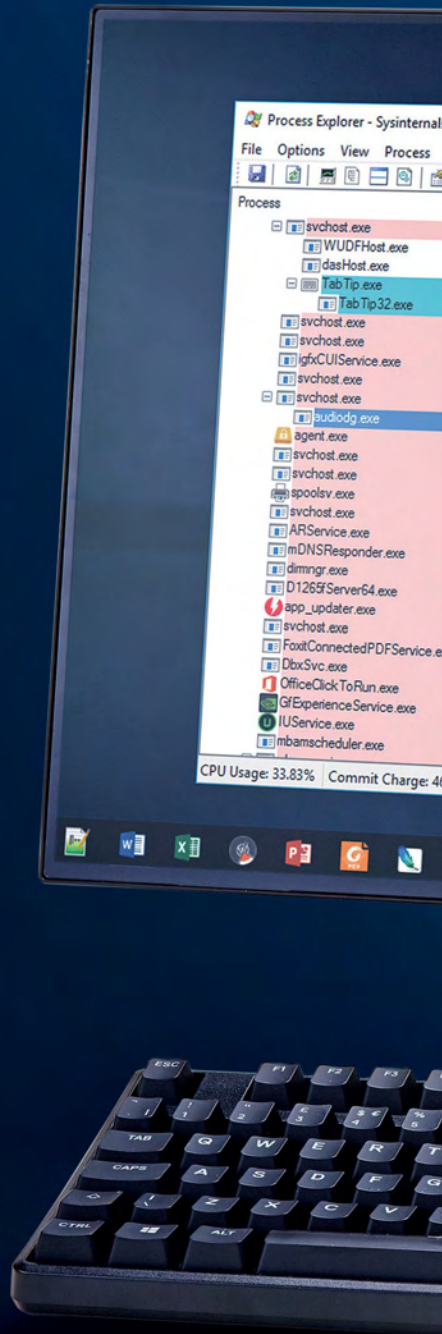
Take a peek at the inner workings of Windows with Task Manager. By *Nick Peers*

Ever wondered what goes on under the hood of Windows? If your PC is running smoothly, doing its job, then probably not. It's when things start to go wrong—your PC slows to a crawl, or non-responsive application errors keep popping up—that you suddenly take a keen interest. There are plenty of tools out there that promise to speed up your computer, fix errors, and make things as good as new again (whatever that means), but there's always an element of risk involved in trusting your PC to a program that doesn't really explain what it's doing, failing to point out that cleaning out the Registry doesn't—on its own, at any rate—speed things up, and, more often than not, introduces problems you later can't unpick to resolve without a refresh or, worse still, full-blown reinstall.

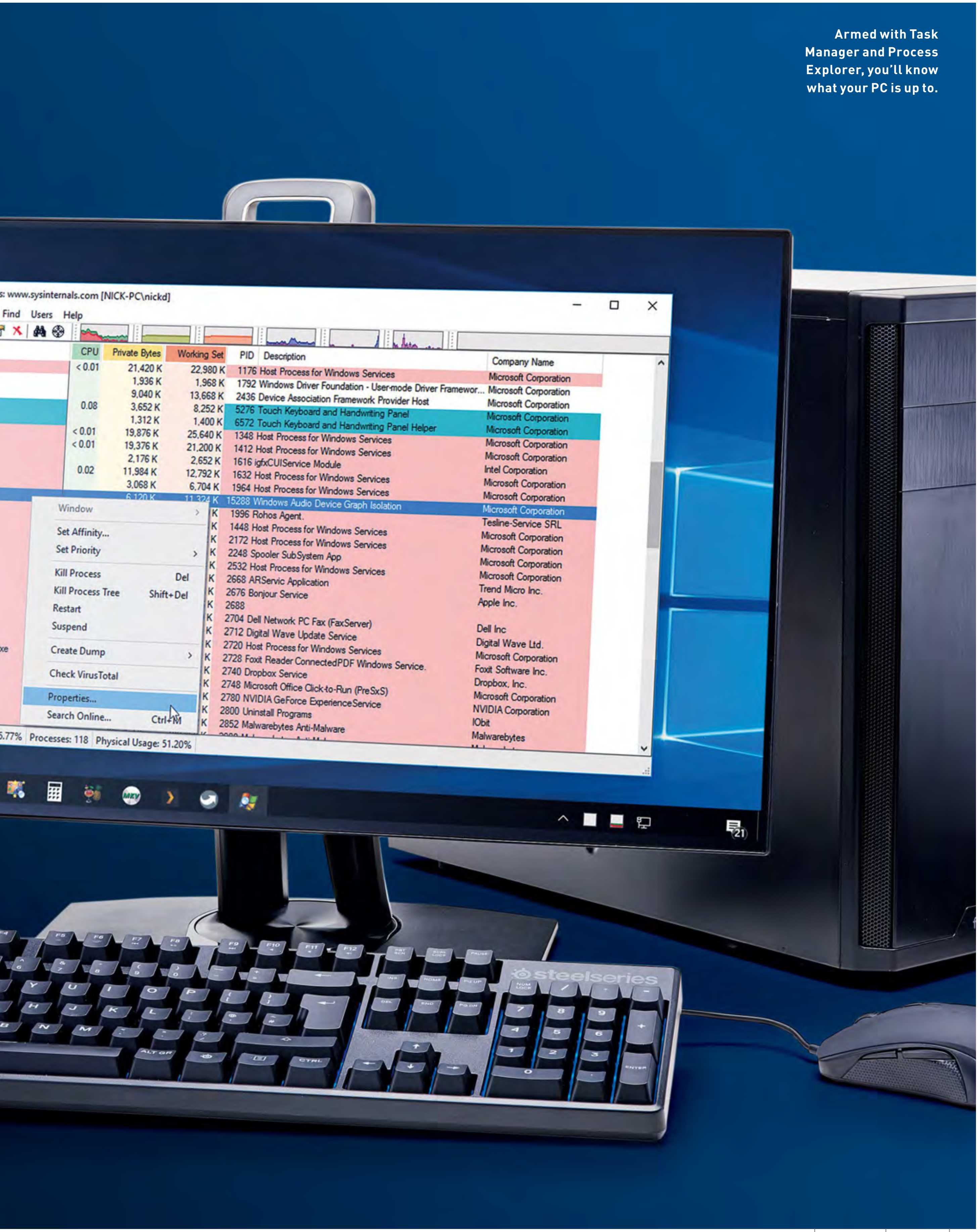
We may live in a post-truth world, but your PC doesn't care about any of that. Knowledge is power, and understanding how Windows works arms you with the insights you need to make more informed choices about what to do the next time your PC decides to slow to a crawl. In this feature, we're going to take a close look at the programs, processes, handles, and threads that make up the bulk of what your PC does. And if all that sounds like gobbledegook, don't worry, because we'll also explain how everything fits together to help you understand exactly what's going on.

We kick things off by having a look at Windows 10's powerful Task Manager tool to take a closer peek—you'll even learn a clever trick that can sometimes help bring frozen applications back to life. And if you want to go deeper, we'll take you on a tour of Process Explorer, which offers a forensic look at exactly what's going on—both in the foreground and behind the scenes. You'll discover how to free up system resources, track down troublesome processes, and generally keep your PC running a bit more smoothly.

We'll also take a brief look at some other tools that can help you monitor your PC and track down fixes to your problems. But enough natter—it's time to arm yourself with the tools and techniques you need to better understand your PC.

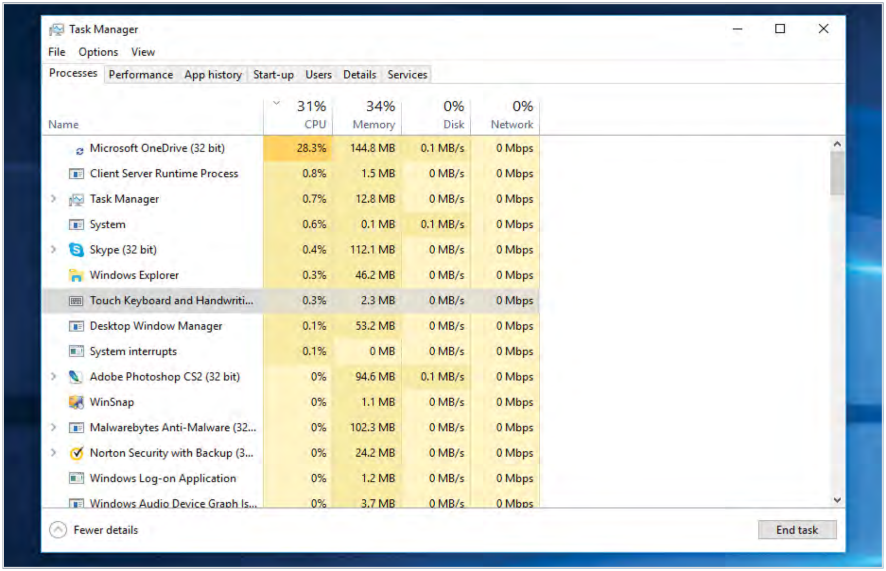

Process Explorer - Sysinternal
File Options View Process
Process
svchost.exe
WUDFHost.exe
dasHost.exe
TabTip.exe
TabTip32.exe
svchost.exe
svchost.exe
igfxCUIService.exe
svchost.exe
svchost.exe
audiodg.exe
agent.exe
svchost.exe
svchost.exe
spoolsv.exe
svchost.exe
ARService.exe
mDNSResponder.exe
dimngr.exe
D1265fServer64.exe
app_updater.exe
svchost.exe
FoxitConnectedPDFService.e
DbxSvc.exe
OfficeClickToRun.exe
GfExperienceService.exe
IUService.exe
mbamscheduler.exe
CPU Usage: 33.83% Commit Charge: 4

Armed with Task Manager and Process Explorer, you'll know what your PC is up to.


s: www.sysinternals.com [NICK-PC\nickd]
Find
Users
Help
Window
Set Affinity...
Set Priority
Kill Process
Del
Kill Process Tree
Shift+Del
Restart
Suspend
Create Dump
Check VirusTotal
Properties...
Search Online...
Ctrl+M
steelseries

CPU	Private Bytes	Working Set	PID	Description	Company Name
< 0.01	21,420 K	22,980 K	1176	Host Process for Windows Services	Microsoft Corporation
	1,936 K	1,968 K	1792	Windows Driver Foundation - User-mode Driver Framewor...	Microsoft Corporation
	9,040 K	13,668 K	2436	Device Association Framework Provider Host	Microsoft Corporation
0.08	3,652 K	8,252 K	5276	Touch Keyboard and Handwriting Panel	Microsoft Corporation
	1,312 K	1,400 K	6572	Touch Keyboard and Handwriting Panel Helper	Microsoft Corporation
< 0.01	19,876 K	25,640 K	1348	Host Process for Windows Services	Microsoft Corporation
< 0.01	19,376 K	21,200 K	1412	Host Process for Windows Services	Microsoft Corporation
	2,176 K	2,652 K	1616	igfxCUIService Module	Intel Corporation
0.02	11,984 K	12,792 K	1632	Host Process for Windows Services	Microsoft Corporation
	3,068 K	6,704 K	1964	Host Process for Windows Services	Microsoft Corporation
	6,120 K	11,324 K	15288	Windows Audio Device Graph Isolation	Microsoft Corporation
		K	1996	Rohos Agent.	Tesline-Service SRL
		K	1448	Host Process for Windows Services	Microsoft Corporation
		K	2172	Host Process for Windows Services	Microsoft Corporation
		K	2248	Spooler SubSystem App	Microsoft Corporation
		K	2532	Host Process for Windows Services	Microsoft Corporation
		K	2668	ARServic Application	Trend Micro Inc.
		K	2676	Bonjour Service	Apple Inc.
		K	2688		
		K	2704	Dell Network PC Fax (FaxServer)	Dell Inc
		K	2712	Digital Wave Update Service	Digital Wave Ltd.
		K	2720	Host Process for Windows Services	Microsoft Corporation
		K	2728	Foxit Reader ConnectedPDF Windows Service.	Foxit Software Inc.
		K	2740	Dropbox Service	Dropbox, Inc.
		K	2748	Microsoft Office Click-to-Run (PreSxS)	Microsoft Corporation
		K	2780	NVIDIA GeForce ExperienceService	NVIDIA Corporation
		K	2800	Uninstall Programs	IObit
		K	2852	Malwarebytes Anti-Malware	Malwarebytes

5.77% | Processes: 118 | Physical Usage: 51.20%



Name	31% CPU	34% Memory	0% Disk	0% Network
Microsoft OneDrive (32 bit)	28.3%	144.8 MB	0.1 MB/s	0 Mbps
Client Server Runtime Process	0.8%	1.5 MB	0 MB/s	0 Mbps
Task Manager	0.7%	12.8 MB	0 MB/s	0 Mbps
System	0.6%	0.1 MB	0.1 MB/s	0 Mbps
Skype (32 bit)	0.4%	112.1 MB	0 MB/s	0 Mbps
Windows Explorer	0.3%	46.2 MB	0 MB/s	0 Mbps
Touch Keyboard and Handwriti...	0.3%	2.3 MB	0 MB/s	0 Mbps
Desktop Window Manager	0.1%	53.2 MB	0 MB/s	0 Mbps
System interrupts	0.1%	0 MB	0 MB/s	0 Mbps
Adobe Photoshop CS2 (32 bit)	0%	94.6 MB	0.1 MB/s	0 Mbps
WinSnap	0%	1.1 MB	0 MB/s	0 Mbps
Malwarebytes Anti-Malware (32...	0%	102.3 MB	0 MB/s	0 Mbps
Norton Security with Backup (3...	0%	24.2 MB	0 MB/s	0 Mbps
Windows Log-on Application	0%	1.2 MB	0 MB/s	0 Mbps
Windows Audio Device Graph Is...	0%	3.7 MB	0 MB/s	0 Mbps

Windows 10's Task Manager provides a decent system overview.

The main focus of our feature is the programs and processes that are running whenever you're using Windows. These include apps, games, and other programs you launch yourself, as well as background processes, such as Windows Services, your security software's auto-protect features, and Windows Explorer itself. Windows ships with its own built-in tool for monitoring and—to some degree—managing all of these in the form of Task Manager.

Task Manager has evolved into quite a powerful tool in recent versions of Windows—launch it by right-clicking the Taskbar. The default basic view merely shows running programs—right-click to close it or switch to that program (handy if it's hidden from view). Note that the "Always on top" option merely ensures that the Task Manager window can't be hidden by other windows.

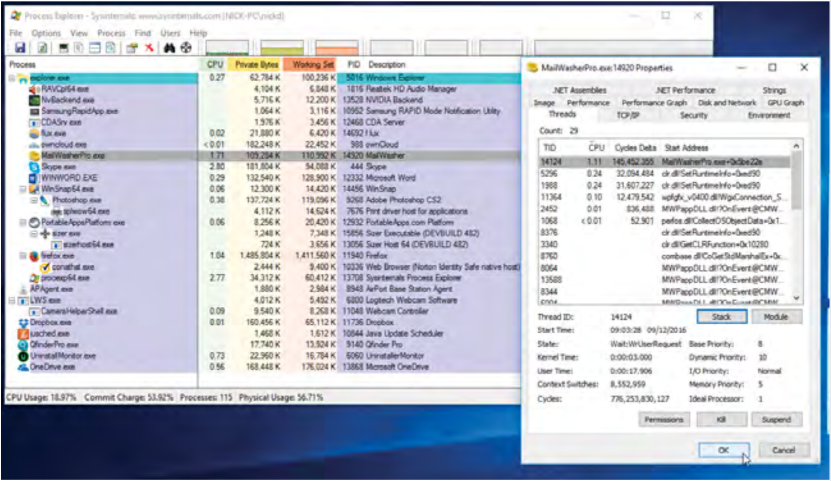
To tap into Task Manager's full range of features, click "More details," which splits things into a multi-tabbed view. The main tab is "Processes," an expanded view of all the processes and threads running on your PC. By default, these are split into three groups: apps are programs you launch from Windows Explorer; background processes are third-party programs running in the background, and Windows processes refer to core processes related to Windows.

You'll see four additional columns of information, labeled "CPU," "Memory," "Disk," and "Network." These represent the process's usage (as a percentage in CPU terms). You can quickly see which processes are hogging system resources by clicking any of the columns to sort the list accordingly. Once identified, you can decide whether or not to close the program or process in question—if you don't recognize its name, right-click it, and choose "Properties → Details" for a more verbose description, or choose "Search online" to search Bing for both the process name and its underlying filename.

Tip: Cloud storage apps often hog all available network resources, which in turn can result in sluggish performance. Once verified as the culprit in Task Manager, open their settings, and look for a section where you can apply limits to their upload and download speeds—OneDrive users should go to "Settings → Network tab," for example.

Recover Frozen Apps

If a program is not responding, the process should be highlighted—from here, you can attempt to close it by selecting the process and clicking the "End task" button. If that's too drastic a step, you may be able to recover it by right-clicking and choosing "Go



Understand Process Terminology

Programs, processes, handles, and threads—what are they, and how do they link together? It can get confusing, particularly given the way that both Task Manager and System Explorer present running programs, processes, and threads.

Programs are a series of files that are combined to provide you with the tools and functionality you use on a daily basis, from a web browser or office package to your game collection. They can also include underlying Windows programs (such as File Explorer) and lower level Services, which work in the background to provide features such as networking and automatic updates.

Processes provide resources to run a program, which are stored in "virtual address space," a reserved portion of RAM. They comprise the program, open "handles" to system objects, which determine what resources are required (such as DLL files), as well as environment variables. Processes are assigned a security context, which determines their level of access to the system, plus a unique process identifier (PID). They're also assigned a priority class, which determines how fast the process runs in relation to other processes. Minimum and maximum "working set sizes" are also applied, to set limits on how much physical memory the process requires.

Each process is split into threads, which allows Windows to allocate CPU time between processes. Each thread can execute any part of the process's code, and shares the process's virtual address space and resources. They have their own properties, such as unique identifiers and exception handlers, and they stop and start to a schedule, so they don't all run at once.

to details." This takes you to the "Details" tab, where processes are listed with more information—their status (running or suspended), the user who launched them (typically you, SYSTEM, or a SERVICE), and a PID (Process ID).

To try to free up a non-responding thread from here, right-click it again, and choose "Analyze wait chain." This lists any threads that are using or waiting to use resources being used elsewhere. Ending the thread may be enough to free up the original process—we've done this a few times in Firefox when an individual tab has become non-responsive, for example.

There are some other handy options under the "Details" tab—you can alter thread priorities here, which in turn can stop particular processes from taking over your PC, and slowing everything else down. Simply right-click the offending process, and choose "Set Priority → Below Normal" to see whether it helps. You can also give threads more priority if you feel they need extra attention, but avoid giving any thread "Realtime" priority, because it brings Windows grinding to a halt.

Another option is "Set affinity." This determines which processor cores a program or service can use—if you have a dual-core CPU or better, you might find older applications designed in the era of single-core processing run better if you limit their access to a specific core, rather than allowing them to use all available cores. In most cases, you'll find Windows is perfectly capable of assigning resources efficiently, so it's of largely academic interest only.

Trim Startup

One other Task Manager tab is worthy of attention: "Start-up." This doesn't just list which programs are set to start with Windows—it provides a "Start-up impact" tab that rates apps' resource usage as "High," "Medium," or "Low." Keep an eye on those rated "High"—if start-up times and overall performance suffer, preventing these from starting with Windows (right-click the program and choose "Disable") may help improve matters.

Task Manager's other tabs enable you to monitor performance over time via a series of graphs ("Performance"), plus keep an eye on apps you've installed through the Microsoft Store by measuring their resource usage over time ("App history"). The "Users" tab is handy when two or more users are logged on at once, providing a list of user-generated running processes. Finally, "Services" provides a cut-down version of which low-level processes are running (or not). You can manually start, stop, and restart services from here, but for more granular control (such as setting a Service's start-up setting), right-click the service, and choose "Open Services."

Process Explorer

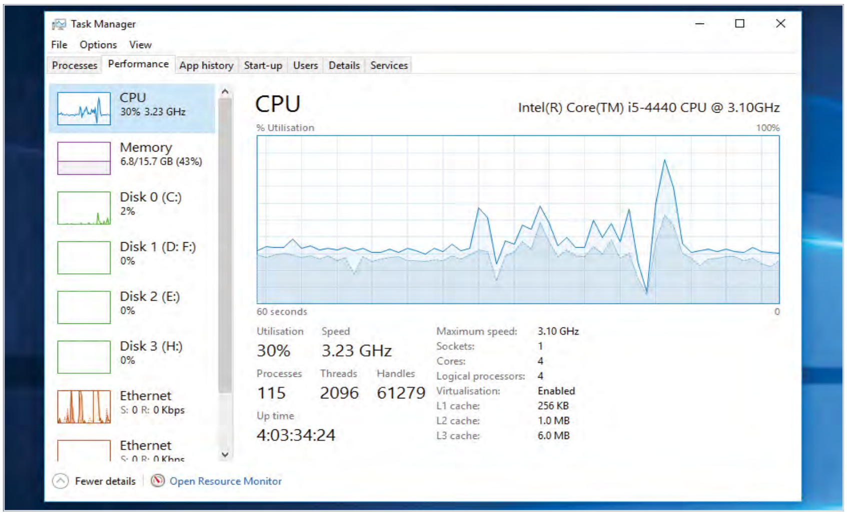
The Windows 10 Task Manager tool goes a long way to giving you a peek inside your system, as well as the tools for dealing with runaway and non-responding programs, processes, and threads. But you can delve even deeper into your system with the help of Process Explorer, a free tool developed by Microsoft's Sysinternals team. Find out more and download it from https://technet.microsoft.com/en-us/sysinternals/processexplorer.aspx—it's completely portable, and can be run directly from your web browser (go to https://live.sysinternals.com/procexp.exe to do so).

We'll assume you're downloading it: once done, right-click "ProcessExplorer.zip," choose "Properties," check "Unblock," and click "OK." Now extract its contents, then right-click either "procexp.exe" or "procexp64.exe" (depending on your Windows system type), and choose "Run as administrator." Process Explorer doesn't require elevated access, but if you want a complete look at your system, you should do so to allow it to peer wherever it needs to.

Process Explorer opens to a single-pane window. Expand the "Options" menu, and check "Hide When Minimized" and "Allow Only One Instance." The former option ensures that when you close or hide Process Explorer, it minimizes to the Taskbar Notification area, where a real-time graph lets you keep an eye on CPU usage (roll your mouse over it, and a pop-up window reveals overall CPU usage, as well as that of the most demanding app running). Go to "Options → Tray Icons" to measure additional metrics via their own system tray icons, with seven choices on offer, including "GPU memory" and "Commit" (total predicted memory the system may need at any one time based on current usage).

Dig Deeper

But we digress. Return to the main Process Explorer window, which lists all running

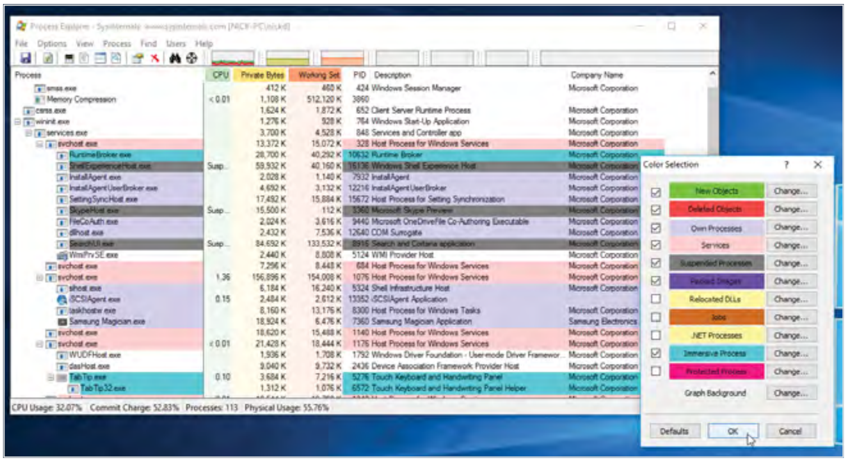


Intel(R) Core(TM) i5-4440 CPU @ 3.10GHz

Utilisation 30%
Speed 3.23 GHz
Processes 115
Threads 2096
Handles 61279
Up time 4:03:34:24

Maximum speed: 3.10 GHz
Sockets: 1
Cores: 4
Logical processors: 4
Virtualisation: Enabled
L1 cache: 256 KB
L2 cache: 1.0 MB
L3 cache: 6.0 MB

Monitor the ups and downs of your system performance with Task Manager.



Process	CPU	Private Bytes	Working Set	PID	Description	Company Name
smss.exe		412 K	460 K	424	Windows Session Manager	Microsoft Corporation
Memory Compression	< 0.01	1,108 K	512,120 K	3860		
csrss.exe		1,624 K	1,872 K	652	Client Server Runtime Process	Microsoft Corporation
wininit.exe		1,276 K	528 K	784	Windows Start-Up Application	Microsoft Corporation
services.exe		3,700 K	4,528 K	848	Services and Controller app	Microsoft Corporation
svchost.exe		13,372 K	15,072 K	328	Host Process for Windows Services	Microsoft Corporation
RuntimeBroker.exe		28,700 K	40,292 K	10632	Runtime Broker	Microsoft Corporation
ShellExperienceHost.exe	Susp...	59,932 K	40,160 K	16136	Windows Shell Experience Host	Microsoft Corporation
InstallAgent.exe		2,028 K	1,140 K	7932	InstallAgent	Microsoft Corporation
InstallAgentUserBroker.exe		4,692 K	3,132 K	12216	InstallAgentUserBroker	Microsoft Corporation
SettingSyncHost.exe		17,492 K	15,884 K	15672	Host Process for Setting Synchronization	Microsoft Corporation
SkypeHost.exe	Susp...	15,500 K	112 K	3360	Microsoft Skype Preview	Microsoft Corporation
FileCoAuth.exe		2,024 K	3,616 K	9440	Microsoft OneDriveFile Co-Authoring Executable	Microsoft Corporation
dllhost.exe		2,432 K	7,536 K	12640	COM Surrogate	Microsoft Corporation
SearchUI.exe	Susp...	84,692 K	133,532 K	8916	Search and Cortana application	Microsoft Corporation
WmiPrvSE.exe		2,440 K	8,808 K	5124	WMI Provider Host	Microsoft Corporation
svchost.exe		7,296 K	8,448 K	684	Host Process for Windows Services	Microsoft Corporation
svchost.exe	1.36	156,896 K	154,008 K	1076	Host Process for Windows Services	Microsoft Corporation
sihost.exe		6,184 K	16,240 K	5324	Shell Infrastructure Host	Microsoft Corporation
iSCSIAgent.exe	0.15	2,484 K	2,612 K	13352	iSCSIAgent Application	
taskhostw.exe		8,160 K	13,176 K	8300	Host Process for Windows Tasks	Microsoft Corporation
Samsung Magician.exe		18,924 K	6,476 K	7360	Samsung Magician Application	Samsung Electronics
svchost.exe		18,620 K	15,488 K	1140	Host Process for Windows Services	Microsoft Corporation
svchost.exe	< 0.01	21,428 K	18,444 K	1176	Host Process for Windows Services	Microsoft Corporation
WUDFHost.exe		1,936 K	1,708 K	1792	Windows Driver Foundation - User-mode Driver Framewor...	Microsoft Corporation
dasHost.exe		3,040 K	9,732 K	2436	Device Association Framework Provider Host	Microsoft Corporation
TabTip.exe	0.10	3,684 K	7,216 K	5276	Touch Keyboard and Handwriting Panel	Microsoft Corporation
TabTip32.exe		1,312 K	1,076 K	6572	Touch Keyboard and Handwriting Panel Helper	Microsoft Corporation

CPU Usage: 32.07% Commit Charge: 52.83% Processes: 113 Physical Usage: 55.76%

☑ New Objects
☑ Deleted Objects
☑ Own Processes
☑ Services
☑ Suspended Processes
☑ Packed Images
☐ Relocated DLLs
☐ Jobs
☐ .NET Processes
☑ Immersive Process
☐ Protected Process
Graph Background

All that color isn't just for decoration—find out what it means.

processes. You'll see some processes are nested inside others in a tree-like structure. This makes it clear from which process a particular process or program spawned (for example, if you open a program in the usual way, it appears nested underneath explorer.exe; however, if you open your web browser by clicking a link in another program—Word, say—it appears underneath the parent program instead).

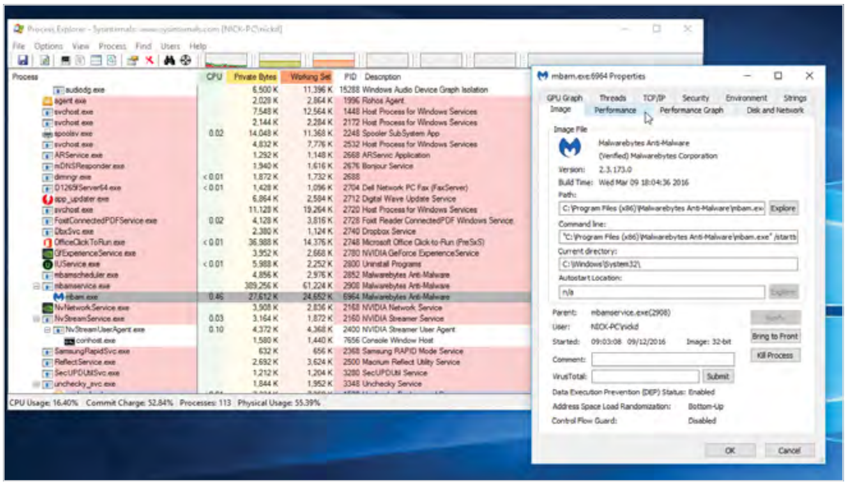
Processes are also color-coded to help you identify what's going on with each—to see what the colors represent, from recently launched threads (green) to threads ending (red), choose "Options → Configure Colors."

Note this view is lost if you click any of the other column headings—such as "CPU"—to determine resource hogs. But if you double-click the process to open its Properties dialog, you can see the name of its parent process underneath the "Image" tab with other useful information (such as which user the process is running under).

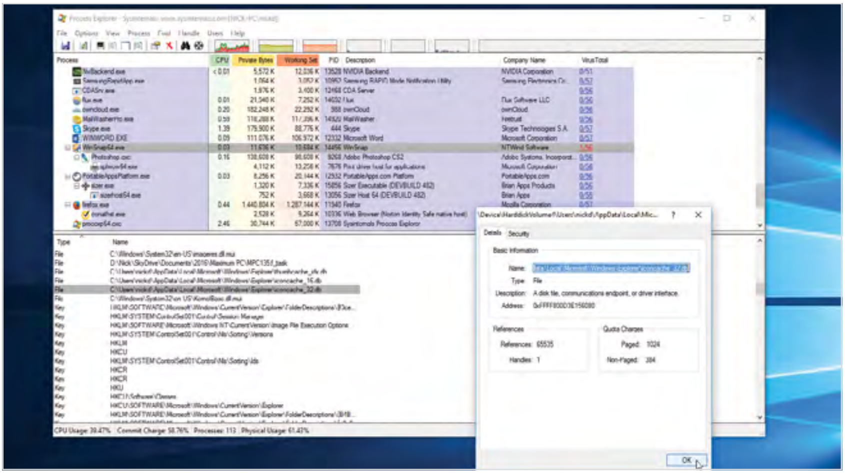
As an aside, look carefully at the System process. You'll see an entry marked "Interrupts." This is an artificial process in that it actually tracks the system's interaction with your hardware. If you spot high CPU consumption for this figure, then it indicates a potential problem with your hardware or—more likely—a driver bug. Don't bother clicking it for further information, though—there's nothing to see, literally.

Microscopic Examination

One of the many ways in which Process Explorer enables you to see what's really



Get the full low-down on any process via its Properties dialog.



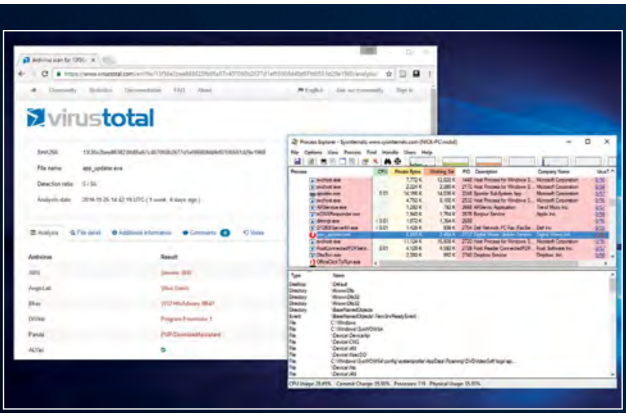
Discover what resources your processes are using via handles.

Check for Malware

Process Explorer can also help track down potential security risks that are running, by comparing a process's parent file with the VirusTotal online database, which checks files against dozens of reputable antivirus engines. Switch the feature on by choosing "Options → VirusTotal.com → Check VirusTotal.com." Click "Yes" to agree to the VirusTotal terms of service (these are displayed in your browser), and then Process Explorer will submit the hashes of every running process and thread to the VirusTotal website. It also adds a new VirusTotal column to the main view. You'll see a list of clickable links reading "0/56" or "3/57." Each one links to the antivirus scan results for that individual file.

Any files listed as "0/57" or similar have been rated safe by all the antivirus engines used; focus your efforts on those marked in red, where the score is 1 or higher. Click the link and you're taken to a web page of results, with the suspected infections placed prominently at the top, along with the source antivirus engine and suspected infection. Google the result, together with the filename, to see what's out there, but unless there are multiple matches, it's likely to be a false positive.

If your file isn't listed there, that means it hasn't yet been scanned by VirusTotal's engines—right-click the file and choose "Submit to VirusTotal" to upload it, then wait for it to be scanned. The results appear in due course.



The more flags on VirusTotal, the more dangerous the file.

You can also check files for their digital signatures—double-click the process and switch to the "Image" tab, then click the "Verify" button. Look for "(Verified)," followed by the name of the digital certificate authority under "Image File." This, on its own, is no guarantee of whether or not a file is safe, but it is an extra layer of security.

happening under the hood is through its support for showing detailed information about a process's threads. Switch to the "Thread tab"—ignoring the warning about missing symbol files (not needed unless you've got the chops to go the extra mile, or you're a developer)—and you'll see a list of all threads associated with that process. You get to see the CPU usage for individual threads, as well as the files calling that thread, which helps pinpoint where a resource leak may be occurring. You can kill or suspend individual threads from this dialog box, but save any work before doing so—you could easily bring down the parent process from here, or even Windows itself if you don't know what you're doing.

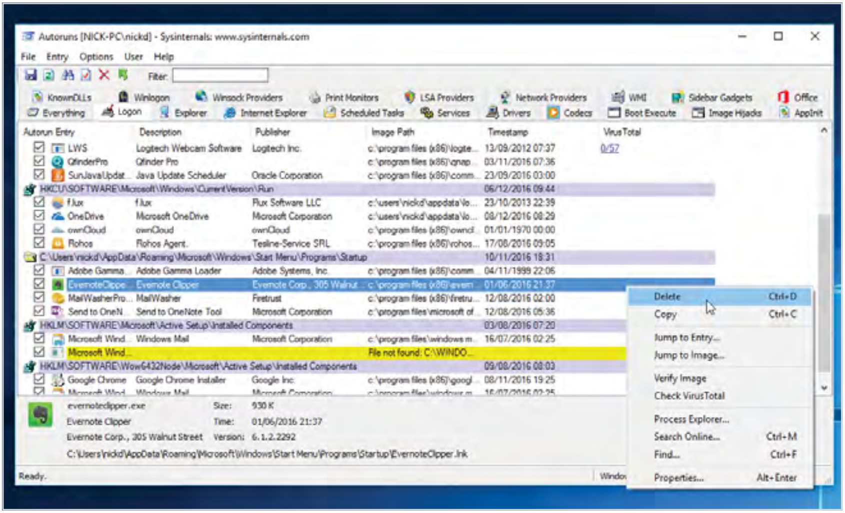
A process's "Properties" dialog contains a wealth of potentially helpful information. Use the "Performance" and "Performance Graph" tabs to measure its impact over time, for example. Switch to the "Service" tab to list which services it utilizes, or select "Environment" to view any environmental variables used by the program. The "Strings" tab is linked to the list of values provided by any DLL files used—these can help identify a process if you're struggling to work out what it relates to.

Handles and DLL Files

Process Explorer also enables you to take a close look at a process's handles and DLL files (the resource files that can be shared between multiple programs). Select your thread and press Ctrl-H—a new pane appears listing its handles. From here, double-click a handle to get more information about it (most specifically, a description of the handle type, such as "Section" or "WindowStation.") It's possible to close individual handles by right-clicking and choosing the "Close" option—but, as with threads, if you don't know what you're doing, it's likely you'll bring the whole process crashing down.

Press Ctrl-D, and this lower pane switches to DLL view, listing all the DLL files that the process in question is accessing. Double-click a DLL file to access its properties—switch to the "Strings" tab and you're shown a list of string values it contains. Press Ctrl-H to switch back to Handles view, or Ctrl-L to toggle the lower pane on and off.

What does this information tell you? It gives you detailed insights into what makes up a process—how it's composed of multiple threads, and what resources it utilizes in the form of handles and DLL files. Not only does it enable you to see exactly what's happening with individual processes, but it also helps you to learn exactly how programs and processes run.



Autorun Entry	Description	Publisher	Image Path	Timestamp	VirusTotal
☑ LWS	Logitech Webcam Software	Logitech Inc.	c:\program files (x86)\logite...	13/09/2012 07:37	0/57
☑ QfinderPro	Qfinder Pro		c:\program files (x86)\qnap...	03/11/2016 07:36	
☑ SunJavaUpdat...	Java Update Scheduler	Oracle Corporation	c:\program files (x86)\comm...	23/09/2016 03:00	
HKCU\SOFTWARE\Microsoft\Windows\CurrentVersion\Run				06/12/2016 09:44	
☑ f.lux	f.lux	Flux Software LLC	c:\users\nickd\appdata\lo...	23/10/2013 22:39	
☑ OneDrive	Microsoft OneDrive	Microsoft Corporation	c:\users\nickd\appdata\lo...	08/12/2016 08:29	
☑ ownCloud	ownCloud	ownCloud	c:\program files (x86)\owncl...	01/01/1970 00:00	
☑ Rohos	Rohos Agent.	Tesline-Service SRL	c:\program files (x86)\rohos...	17/08/2016 09:05	
C:\Users\nickd\AppData\Roaming\Microsoft\Windows\Start Menu\Programs\Startup				10/11/2016 18:31	
☑ Adobe Gamma...	Adobe Gamma Loader	Adobe Systems, Inc.	c:\program files (x86)\comm...	04/11/1999 22:06	
☑ EvernoteClippe...	Evernote Clipper	Evernote Corp., 305 Walnut...	c:\program files (x86)\evern...	01/06/2016 21:37	
☑ MailWasherPro...	MailWasher	Firetrust	c:\program files (x86)\firetru...	12/08/2016 02:00	
☑ Send to OneN...	Send to OneNote Tool	Microsoft Corporation	c:\program files\microsoft of...	12/08/2016 05:36	
HKLM\SOFTWARE\Microsoft\Active Setup\Installed Components				03/08/2016 07:20	
☑ Microsoft Wind...	Windows Mail	Microsoft Corporation	c:\program files\windows m...	16/07/2016 02:25	
☑ Microsoft Wind...			File not found: C:\WINDO...		
HKLM\SOFTWARE\Wow6432Node\Microsoft\Active Setup\Installed Components				09/08/2016 08:03	
☑ Google Chrome	Google Chrome Installer	Google Inc.	c:\program files (x86)\googl...	08/11/2016 19:25	
☑ Microsoft Wind...	Windows Mail	Microsoft Corporation	c:\program files\windows m...	16/07/2016 02:25	

evernoteclipper.exe Size: 930 K
Evernote Clipper Time: 01/06/2016 21:37
Evernote Corp., 305 Walnut Street Version: 6.1.2.2292
C:\Users\nickd\AppData\Roaming\Microsoft\Windows\Start Menu\Programs\Startup\EvernoteClipper.lnk

For more granular control over your startup, check out Autoruns.

Get More Help

Process Explorer is a powerful tool, and it can take a while to get your head around it. The Help file is a good place to start—press F1 to access it—but you'll find some handy online resources, too. There's a PDF handout from Kansas State University (http://bit.ly/procexplhandout) that provides a good introduction—it was written back in 2009, but is still relevant. And don't forget the official Process Explorer forum (http://forum.sysinternals.com), which contains an FAQ, among other handy resources.

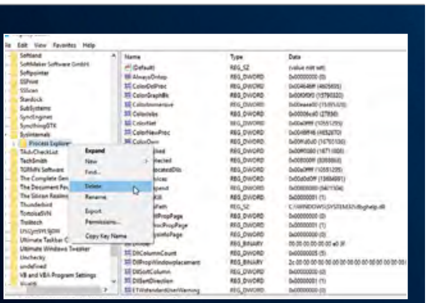
It's also worth taking a look at some of Sysinternals' other tools as well—Autoruns (http://bit.ly/autoruns) gives you a similarly detailed view of the start-up process, split across major tabs. It's easier to grasp than Process Explorer, and provides you with all the tools you need to streamline your startup. If you want to monitor file system, Registry, process, thread, and DLL activity in real time, then Process Monitor (http://bit.ly/processmonitor) is the tool to go for—this is particularly handy if a program is crashing, because it provides you with more detail as to where in the process things might be going wrong. Finally, RAMMap (http://bit.ly/ram-map) lets you take a peek into how your system RAM is managed.

Process Explorer Tips and Tricks

Struggling to identify a window's parent process or thread? Open Process Explorer, then drag the target-like icon next to the binoculars icon on to the window in question, and its associated thread is highlighted.

Click the binoculars icon or press Ctrl-F to open the search tool—this enables you to search by handle or DLL substring to see which processes are using (and possibly holding on to) resources. If you can't access a file because "it's open in another program," this can find what's locking it.

Choose "View → Select Columns," and you'll see you can view pretty much any kind of data about a process or thread that you want. Most useful views can be found on the "Process Image" (for additional info about the process) and "Process Performance" tabs (check "CPU History," for example, to track a process's resource consumption over time on a graph). Many of these options are overkill, but Google any terms to find out more about them. Also take the time to look at the "Handles" and "DLL" tabs—you can add extra information to both panes.



We like running Task Manager and Process Explorer together, but if Process Explorer offers all the functionality you need, you can make it your default task manager—choose "Options → Replace Task Manager." Now, pressing Ctrl-Alt-Del or right-clicking the Taskbar and choosing "Task Manager" launches Process Explorer.

Should you wish to reset Process Explorer to its defaults, right-click its system tray icon, and choose "Close Process Explorer." Press Win-R, type "regedit," and hit Enter. Navigate to "HKEY_CURRENT_USER\SOFTWARE\Sysinternals." Right-click the "Process Explorer" subkey, choose "Delete," then close Registry Editor.

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TECH PORN

Asus PA329Q Monitor

IN SEARCH OF INCREDIBLE—that's Asus's MO, a subtle nod to a lifetime dedicated to the pursuit of mastering everything hardware-related. From graphics cards to motherboards, and gaming peripherals to high-end workstation products, the Taiwanese company has certainly made an impact on the tech world, garnering huge sales figures across the globe.

But don't be fooled—this isn't an organization hell-bent on being a jack of all trades and master of none. Asus's products are renowned for their premium feel and exceptional quality, and that's particularly true of its range of monitors. Whether that's introducing one of the first high refresh rate gaming monitors, or pushing IPS panels into the mainstream, Asus has championed the humble pixel's potential to achieve the pinnacle of success in today's graphical world.

The Asus PA329Q is the absolute zenith of what can be achieved with a professional grade monitor in today's computing age. Featuring a quantum dot 4K IPS display for near-perfect color reproduction, this 32-inch artist's dream is nothing short of awe-inspiring. The design of this elegant-yet-simple display inspires confidence, with a subtle hint of copper gracing that sharp-lined bezel that surrounds the panel. It's not cheap—$1,250 if you please—but when you're in search of the incredible, sacrifices always have to be made. **–ZAK STOREY**

ProArt
HDMI

1 STYLISH DESIGN
Thirty-two inches of beautiful design, capped off with a super-slim bezel, lined with a copper element. It's hard not to love the stylized finish on the PA329Q.

2 4K IPS PANEL

A true piece of beauty. This quantum dot 4K 32-inch 10-bit panel comes with a 99.5 percent Adobe RGB color gamut, a 5ms G2G response time, and—thanks to that 10-bit panel depth—HDR (on graphics cards that support it).

3 FULLY ADJUSTABLE

Up, down, left, right, rotate, swivel: You name it, this monitor's got it. Need it in portrait mode? No problem. Horizontal for video production? Done. 100mm VESA mount? Yep, that too.

GAMES FOR 2017

Keeping the PC ahead of the pack

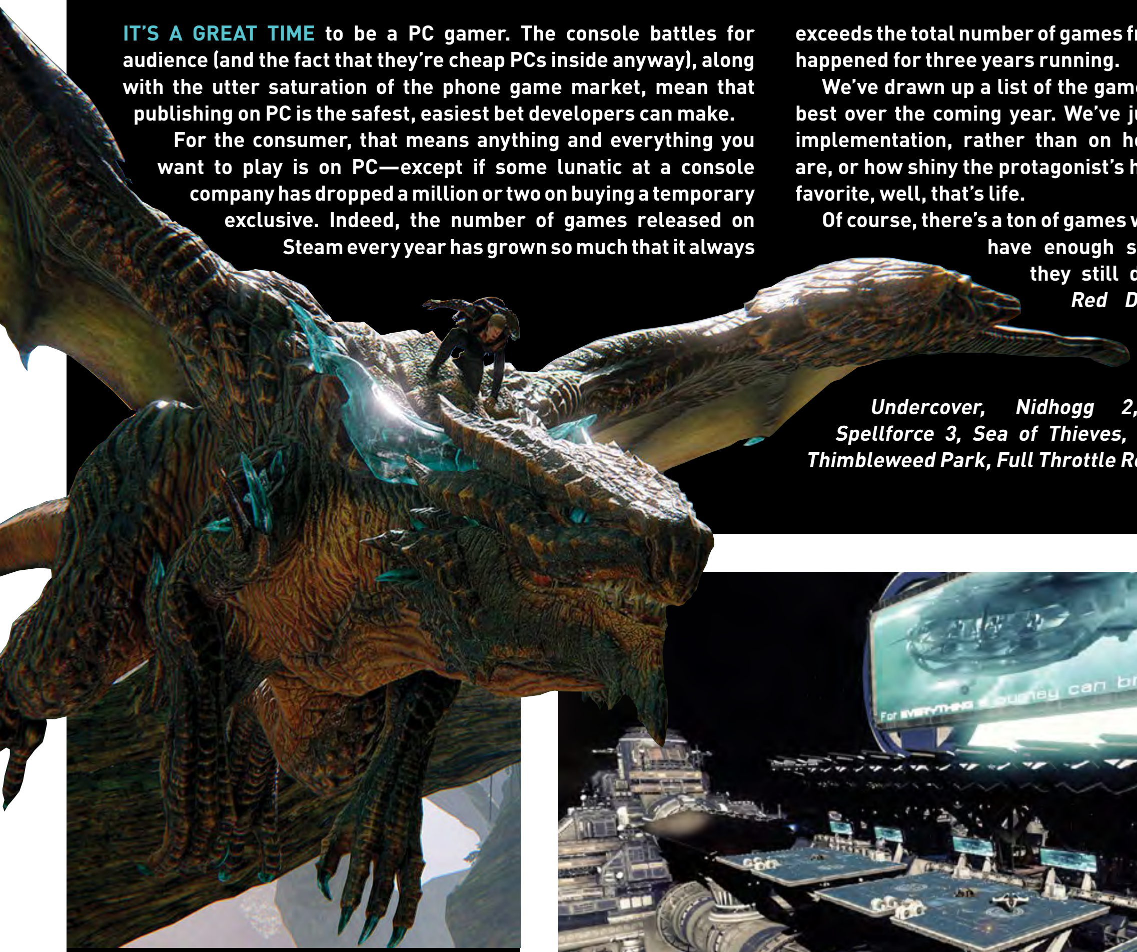
BY DAN GRILIOPOULOS AND ALAN DEXTER

IT'S A GREAT TIME to be a PC gamer. The console battles for audience (and the fact that they're cheap PCs inside anyway), along with the utter saturation of the phone game market, mean that publishing on PC is the safest, easiest bet developers can make.

For the consumer, that means anything and everything you want to play is on PC—except if some lunatic at a console company has dropped a million or two on buying a temporary exclusive. Indeed, the number of games released on Steam every year has grown so much that it always exceeds the total number of games from previous years—and that's happened for three years running.

We've drawn up a list of the games we think are going to be the best over the coming year. We've judged them on innovation and implementation, rather than on how convincing their bullshots are, or how shiny the protagonist's hair looks. If we've missed your favorite, well, that's life.

Of course, there's a ton of games we did want to include but didn't have enough space or enthusiasm for—but they still deserve a mention: *Tekken 7, Red Dead Redemption 2, World's Adrift, Vampyr, Bloodstained, Quake Champions, Kingdom Come: Deliverance, Lego City Undercover, Nidhogg 2, Mu Cartographer, Battle Chef, Spellforce 3, Sea of Thieves, The Church in the Darkness, Thimbleweed Park, Full Throttle Remastered,* and *Xenonauts 2.*



Scalebound **Release date: 2017**

An action RPG in which you have a giant noble dragon as a sidekick, which you can order about or take direct control of. Using your dragon, you explore the strange world of Draconis, and defeat the enemies that threaten it and Earth. Combat is combo-driven, and the game can be played through in co-op—though you each have your own dragon.

» **Publisher:** Microsoft

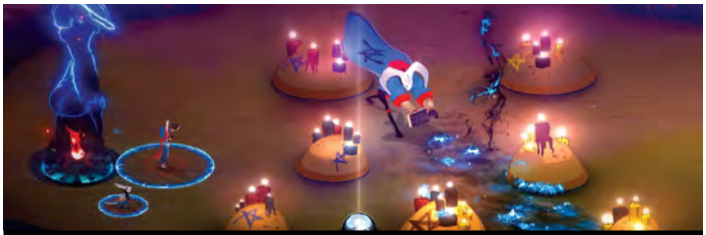
» **Developer:** Platinum

RSI
For EVERYTHING a journey can bring

Star Citizen **Release date: TBC**

Star Citizen is Chris "Wing Commander" Roberts' return to video games. It's actually two games in one: a single-player/co-op FPS campaign packed with Hollywood stars such as Gary Oldman, Gillian Anderson, and Mark Hamill, and a massively multiplayer FPS/combat/trading/exploration game in a huge persistent universe. It's built on the CryEngine, so it's pretty as sin, and supports all the VR headsets. It's also ridiculously ambitious.

» **Publisher & Developer:** RSI

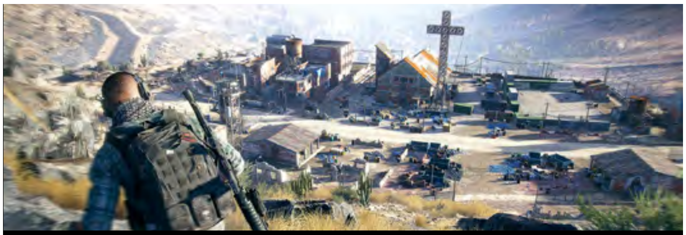


Pyre

Release date: 2017

Supergiant made its name with the stunning isometric action games *Bastion* and *Transistor. Pyre* returns to a fantasy world with a 1980s cartoon style. You play The Reader, leading a trio of exiles across a purgatorial land. Its USP is that it includes text adventure elements, and the combat system is like three-person fantasy basketball.

» **Publisher & Developer:** Supergiant

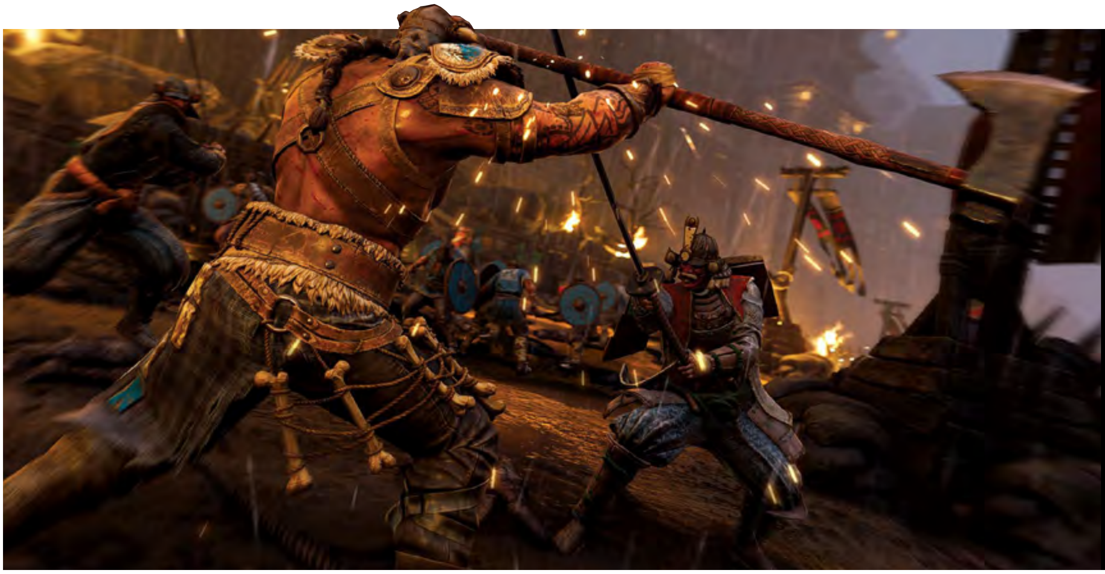


Tom Clancy's Ghost Recon Wildlands

Release date: March 7, 2017

Tom Clancy may have passed away, but his dystopian militarism continues. Ubisoft has said that *Wildlands* is one of the biggest open-world games it has ever created, including mountains, forest, deserts, and salt flats, scattered across Bolivia.

» **Publisher:** Ubisoft » **Developer:** Ubisoft Paris



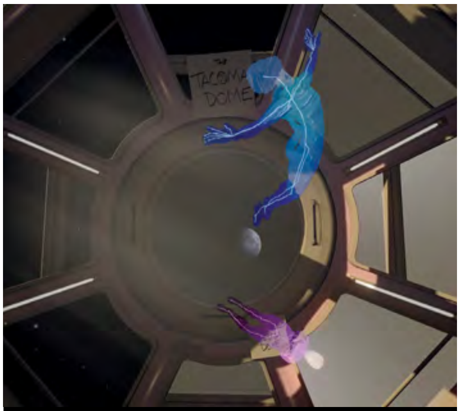
For Honor

Release date: Feb 14, 2017

A medieval combat/beat-'em-up historical mash-up. Players take control of a Viking, Samurai, or Knight in multiplayer battles, often alongside weaker NPC minions. There are three single-player or co-op campaigns, too. Combat is the game's most ambitious aspect: Players must match the direction of each other's attacks to defend or parry.

» **Publisher:** Ubisoft

» **Developer:** Ubisoft Montreal

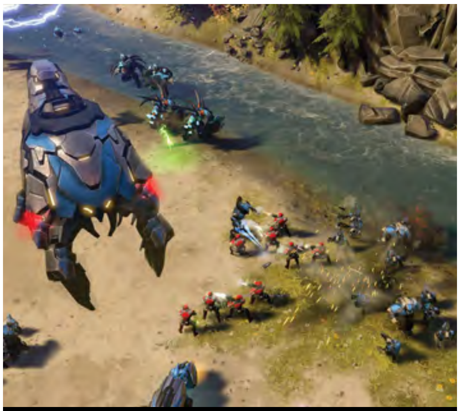


Tacoma

Release date: Early 2017

Fullbright's *Gone Home* was acclaimed for its depiction of a mysteriously abandoned suburban American home. Its next game steps a million miles from the parochial, taking its first-person abandoned mystery into space. Reminiscent of *Solaris* and *Everybody's Gone To The Rapture*, you explore the augmented reality traces of a space station's staff on their last day.

» **Publisher & Developer:** Fullbright



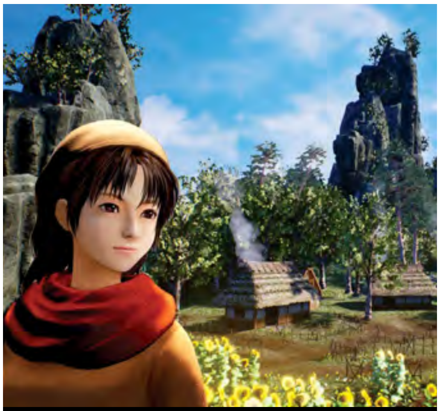
Halo Wars 2

Release date: February 21, 2017

This is an old-fashioned RTS, in the style of *Starcraft II*, where you control two factions. It features a large array of FPS-inspired multiplayer modes, ranging from co-op skirmish modes, to deathmatch, Capture-And-Hold, and an innovative deck-building mode called Blitz.

» **Publisher:** Microsoft

» **Developer:** Creative Assembly



Shenmue 3

Release date: December 2017

In 1999, *Shenmue* was the most expensive video game ever, estimated to have cost Sega over $47 million. This time, it has raised $6.6 million from crowdfunding. *Shenmue III* is an open-world action adventure, where you battle beat-'em-up enemies and quick time events.

» **Publisher:** Ys Net

» **Developer:** Neilo/Ys Net

Yooka-Laylee

Release date: April 11, 2017

Among PlayStation players of a certain generation, Rare's platform games are thought about with fond nostalgia. *Yooka-Laylee* is the spiritual sequel to those games, created by former Rare employees. You take control of the chameleon Yooka and the bat Laylee, as they explore worlds contained in magical books, collecting Pagies, in an attempt to prevent a corporate overlord from destroying all the books.

- » **Publisher:** Team 17
- » **Developer:** Playtonic

Call of Cthulhu

Release date: 2017

Lovecraft's Cthulhu mythos has spawned many imitators, but surprisingly few games. This release is based on the 1981 tabletop role-playing game. Like the books, the game is an investigation that quickly turns into horror, where players must strive to penetrate the secrets of a cult that's taken over a small fishing town.

- » **Publisher:** Focus Home Interactive
- » **Developer:** Cyanide

Prey

Release date: Summer 2017

Prey already looks like this year's best blockbuster, a spiritual sequel to *System Shock*. It's an FPS/RPG set in an alternate timeline, where the US fully funded the 1960s space program, before Earth was attacked by aliens. Cut to 2032, and Morgan Yu finds himself inside a space station, using every weapon and resource he can to survive against bizarre aliens.

- » **Publisher:** Bethesda
- » **Developer:** Arkana

Resident Evil 7

Release date: January 24, 2017

Capcom has started anew with *Resident Evil 7,* shifting to first-person horror, reminiscent of the classic *Condemned.* Set in rural America four years after the last game, you control Ethan, a man searching for his missing wife. Soon enough, he encounters mutant creatures he has to put down with shotguns, flamethrowers, chainsaws, and the like.

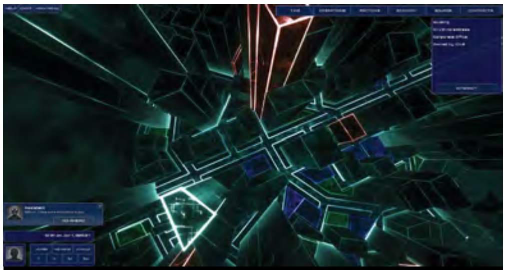
- » **Publisher & Developer:** Capcom

Absolver

Release date: 2017

Created by a bunch of ex-Ubisoft Paris developers, *Absolver* is a highly technical martial arts and role-playing game with an impressionistic art style and palette. Players learn attacks, feints, and parries, which they can build into combos. These switch them between stances, so combat is fluid and very quickly fatal. Players can fight with or alongside other human players—or even spar to teach other new moves.

- » **Publisher:** Devolver
- » **Developer:** Sloclap

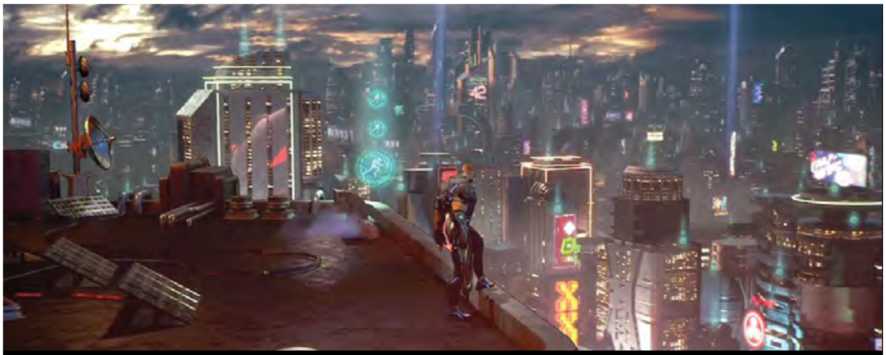


Frozen Synapse 2

Release date: 2017

Frozen Synapse was a great implementation of the turn-based combat mechanics of games such as *XCOM* and *Laser Squad*, with a twist. *Frozen Synapse 2* is where Mode 7 gets to show off its own ideas, taking place in a giant procedurally-generated cyberpunk city.

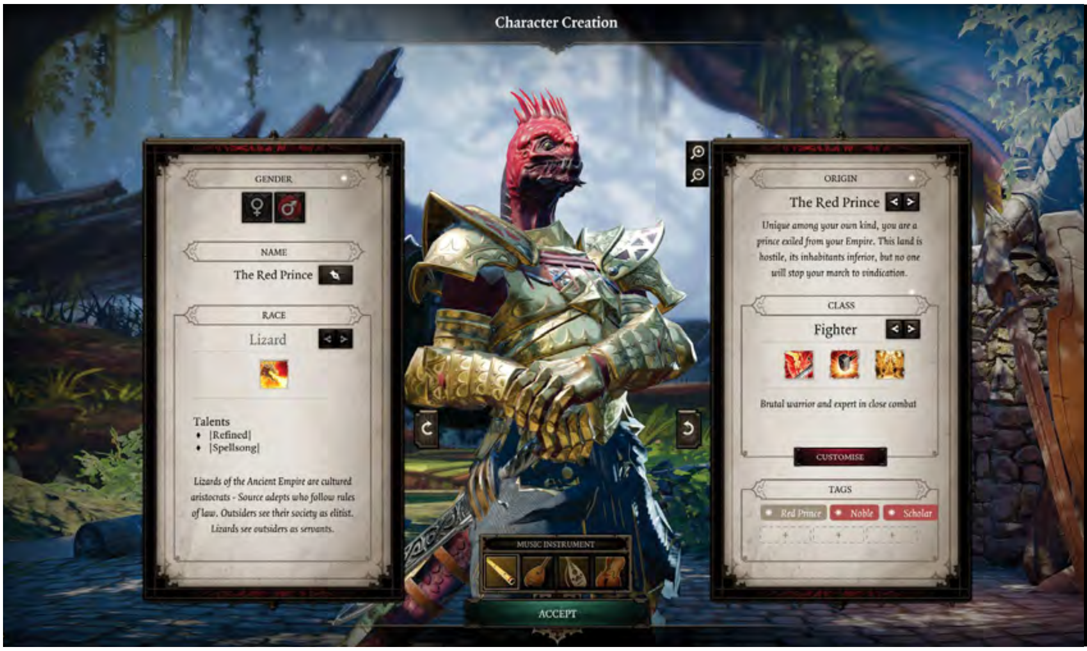
» **Publisher & Developer:** Mode 7



Crackdown 3 **Release date: 2017**

PC gamers didn't get to try the previous *Crackdowns*, but the first was one of the best Xbox 360 exclusives. Up to 99 players take control of a superpowered cop, with total impunity to take down gangs that have taken over his city. With an impressive arsenal, the power of cloud computing is being used to make the entire city destructible.

» **Publisher:** Microsoft » **Developer:** Reagent Games



NAME: The Red Prince

RACE: Lizard

Talents
- |Refined|
- |Spellsong|

Lizards of the Ancient Empire are cultured aristocrats - Source adepts who follow rules of law. Outsiders see their society as elitist. Lizards see outsiders as servants.

ORIGIN: The Red Prince

Unique among your own kind, you are a prince exiled from your Empire. This land is hostile, its inhabitants inferior, but no one will stop your march to vindication.

CLASS: Fighter

Brutal warrior and expert in close combat

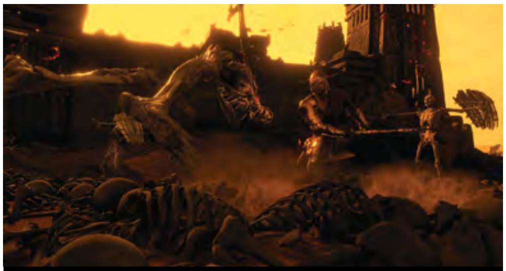
TAGS: Red Prince, Noble, Scholar

Divinity: Original Sin 2

Release date: 2017

Divinity: Original Sin was a huge open-world game, with innovative character classes, magical systems, and combat. This sequel has been in early access since Fall 2016, and expands on the original in every way. You can play almost any race, talk to anyone, go anywhere, interact with anything, kill any NPC, destroy any object.... Its story follows a wielder of forbidden magic, battling a divine order, seeking to establish a new god.

» **Publisher & Developer:** Larian Studios



Conan Exiles **Release date: 2017**

Funcom made the *Age of Conan* MMOG in 2008; now it's returning to the world of the barbarian hero with *Conan Exiles*, an open-world survival game, which works in both single- and multiplayer. As an exile, you plunder ancient ruins and shelter from brutal sandstorms. Survive, and you can build your clan's legacy.

» **Publisher & Developer:** Funcom

Torment: Tides of Numenera **Release date: Feb 28, 2017**

It might not be a straight sequel to 1999's *Planescape: Torment*, but as a spiritual sequel with much of the old team involved, this is definitely exciting. It's a party-based RPG, where the focus is on choice, interaction, and story—not necessarily combat. You play the Last Castoff, the erstwhile host body of a godlike human, now abandoned and forever changed by the experience, who must find his immortal predecessor.

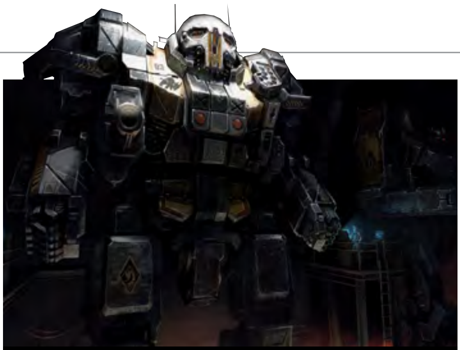
» **Publisher:** Techland » **Developer:** inXile Entertainment

Dawn of War III

Release date: 2017

Games Workshop's video game adaptations seem everywhere now, but the *Dawn of War* RTS series is the longest-running. *Dawn of War III* promises to bring the series up to date, with even bigger battles, featuring some returning friends.

» **Publisher:** Sega » **Developer:** Relic



BattleTech

Release date: 2017

Good news for old-school tabletop gamers: *BattleTech/Mechwarrior* is back. The player takes control of a squad of Battlemechs, choosing their loadout, and taking them to turn-based war in the service of one of the world's noble houses.

» **Publisher & Developer:** Harebrained Schemes

The Signal from Tolva

Release date: 2017

You control a surveyor robot on a planet dotted with the titanic remains of fallen civilizations. The focus on controlling, fighting, and killing other robots is a step away from the disempowerment of Big Robot's *Sir, You Are Being Hunted.*

» **Publisher & Developer:** Big Robot

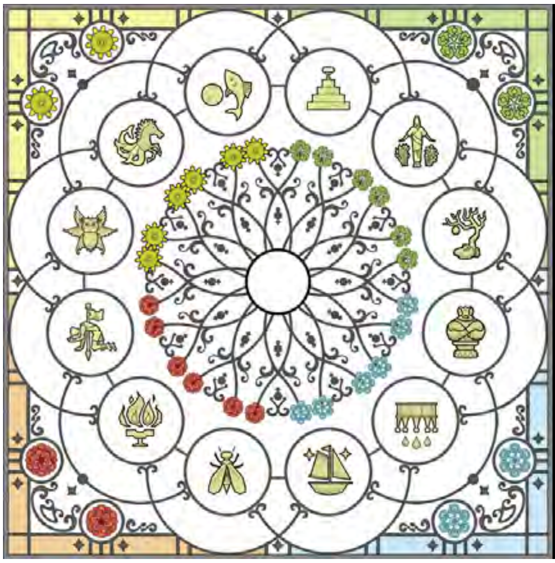
Agents of Mayhem

Release date: 2017

Volition was well respected before its *Saints Row* series copied *GTA* and (whisper it) improved on it. Now it's establishing a new series, albeit still in the *Saints Row* universe. You take the part of three heroes, fighting the criminal masterminds of LEGION, in Seoul, an open world full of missions, doomsday devices, and underground lairs. You can swap between agents easily in the field, and customize them to create a hero dream team.

» **Publisher:** Deep Silver

» **Developer:** Volition



Gorogoa

Release date: TBC

There are plenty of strange indie titles due in 2017, but *Gorogoa* has been on our watchlists for years. Players are presented with four images in a grid, and must combine and explore each image to discover their connection and continue exploring. There's no help, the game is drawn in an unusual *fin de siècle* style, and it's wordless.

» **Publisher:** Annapurna Interactive

» **Developer:** Jason Roberts

Tokyo 42

Release date: Early 2017

Tokyo 42 is a beautiful combat puzzle game. You take the part of an assassin, and must mingle stealth, bullet physics, acrobatic jumping, and cover in simulated crowds, as you close in on your target. Single-player has you following a wannabe assassin getting embroiled with sinister forces, while multiplayer mixes stealth and lethality for a perfect lunchbreak game.

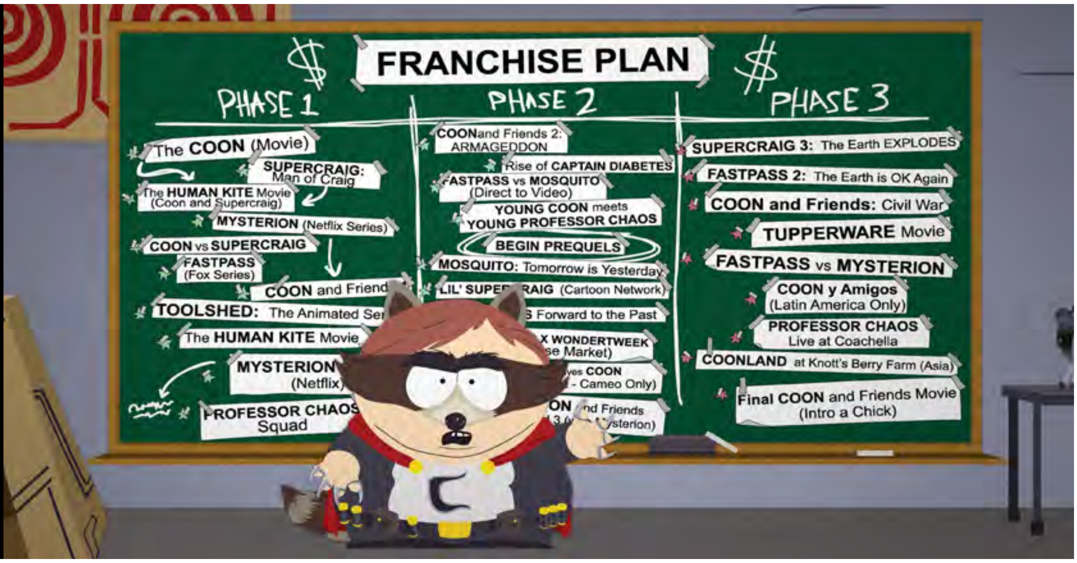
» **Publisher:** Mode 7 » **Developer:** SMAC Games

South Park: The Fractured But Whole

Release date: Early 2017

Ubisoft's previous *South Park* game was a perfect translation of *South Park* to a… turn-based RPG? This time, the kids are imitating superheroes in their make-believe, and you, as the New Kid, have to intervene in the brewing civil war between the heroes, and defeat the dark power behind it. Oh, and your superpower is farts.

» **Publisher:** Ubisoft
» **Developer:** Ubisoft San Francisco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PHASE 2
PHASE 3
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SUPERCRAIG: Man of Craig
The HUMAN KITE Movie (Coon and Supercraig)
MYSTERION (Netflix Series)
COON vs SUPERCRAIG
FASTPASS (Fox Series)
COON and Friend
TOOLSHED: The Animated Ser
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MYSTERION (Netflix)
PROFESSOR CHAOS Squad
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MOSQUITO: Tomorrow is Yesterday
LIL' SUPER RAIG (Cartoon Network)
Forward to the Past
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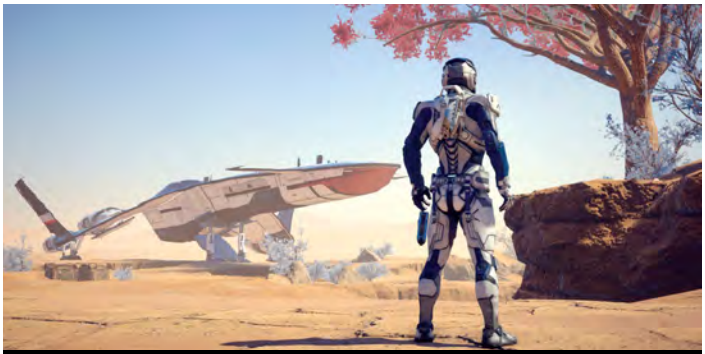
Final COON and Friends Movie (Intro a Chick)

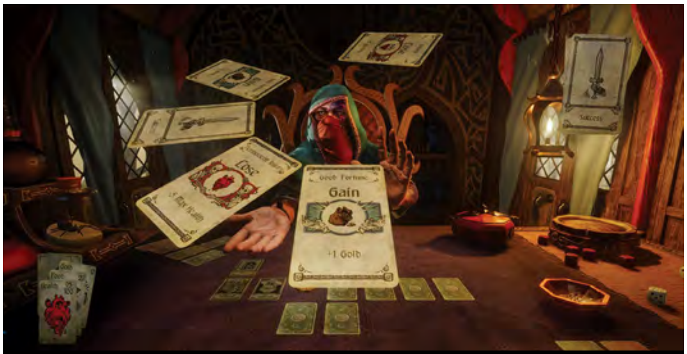


Mass Effect: Andromeda

Release date: 2017

Mass Effect 3 controversially ended Bioware's *Mass Effect* series, halting the story of Commander Shepard and his battle against the Reapers. Now, the story continues in a new galaxy, 600 years later, where humanity is seeking to find new homes. You play Pathfinder Ryder, exploring this open-world galaxy in your starship, or on the surface of planets in your buggy, or on foot with a team. You can fight, reason with, and romance many of the characters you meet.

» **Publisher:** EA » **Developer:** Bioware

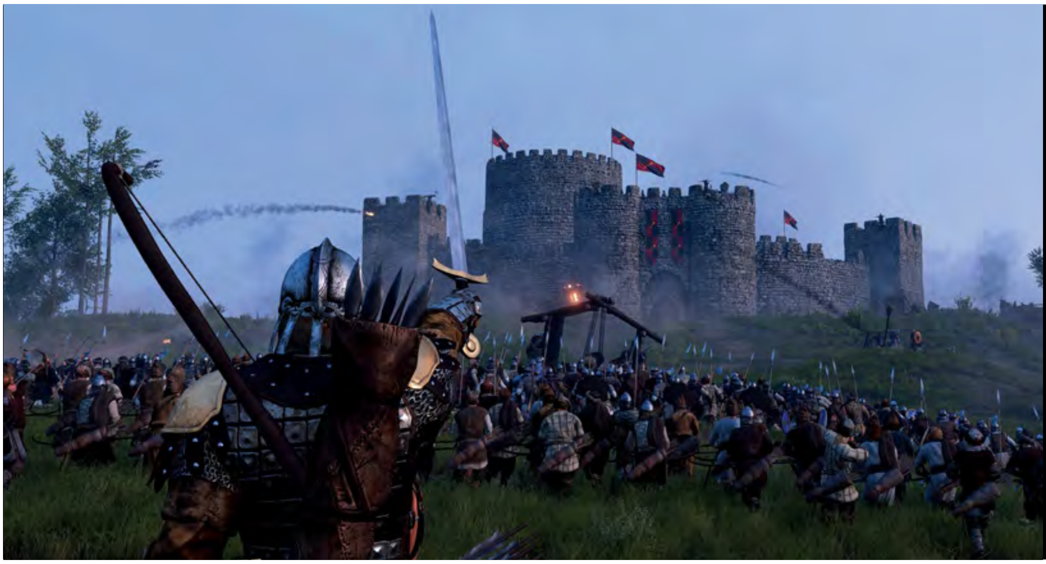


Hand of Fate 2

Release date: Early 2017

Hand of Fate was something from a fairy tale. You sat facing a masked stranger. He dealt you cards, then lay out more, like a tarot, taunting you as they landed. Every card you turned over was another event, a quick action adventure battle or a text adventure. Win and you could play more games; lose and…. *Hand of Fate 2* promises more of the same, adding companions, new challenges, and new opponents. And much higher stakes than just your life….

» **Publisher & Developer:** Defiant Development



Mount & Blade II: Bannerlord

Release date: TBC

Mount & Blade: Warband quietly established itself as an indie behemoth. A bodged-together bunch of systems, it enabled you to take part in realistically bloody battles. *Bannerlord* promises much more polish. It expands the charmingly rudimentary fighting system of the first game, and its world. New to the game are siege warfare, diplomacy, and a working economy, adding to its hugely complex world.

» **Publisher & Developer:** TaleWorlds Entertainment

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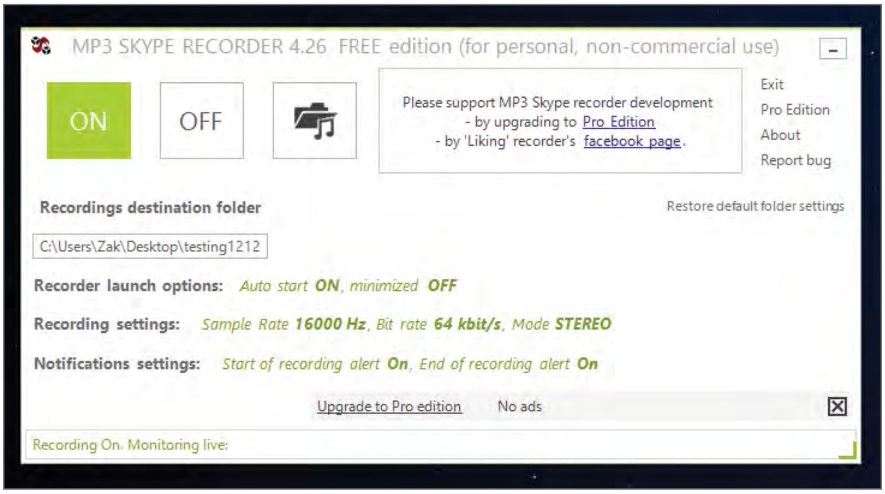

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Recorder launch options: Auto start ON, minimized OFF

Recording settings: Sample Rate 16000 Hz, Bit rate 64 kbit/s, Mode STEREO

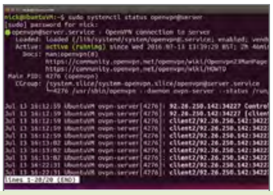
Notifications settings: Start of recording alert On, End of recording alert On

Recording On. Monitoring live:

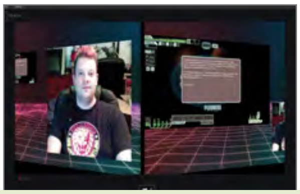
SKYPE RECORDING

Use Skype a lot? If you like to keep a backup of your calls, a nifty piece of freeware called MP3 Skype Recorder is exceptionally handy. It monitors your Skype account, looking for audio activity, and as soon as a call starts, it begins recording the session for you to play back later. There's also an ad-free Pro version for business use, with extra features, that costs less than two cups of coffee. https://mp3skyperecorder.com

MAKE – USE – CREATE



58
Connect to the Internet securely with OpenVPN



62
Create professional streams with Gameshow

68
Follow the build process behind our brand new test bench

ZAK STOREY
REVIEWS EDITOR

BOOT TIMES

It only seems like yesterday that I would hit the switch on my BitFenix Shinobi, make a run for the throne, grab a drink, and head back to my room at varsity, waiting for my system to boot into life. An SSD was the solution to those waits. It annexed the ancient hard drive, enabling booting from UEFI to login screen in less time than it takes to identify the console gamer in the room (about 10 seconds).

Things have improved drastically since those first SSDs. PCIe SSDs are now available to the masses, which, on paper, should be far faster than any SSD from days past. The latest budget 250GB Samsung Evo 960 comes with sequential reads of 3,200MB/s—six times faster than the height of SSD power, with reads being the key factor when looking at boot times. However, in my experience, it doesn't correlate well when it comes to boot times.

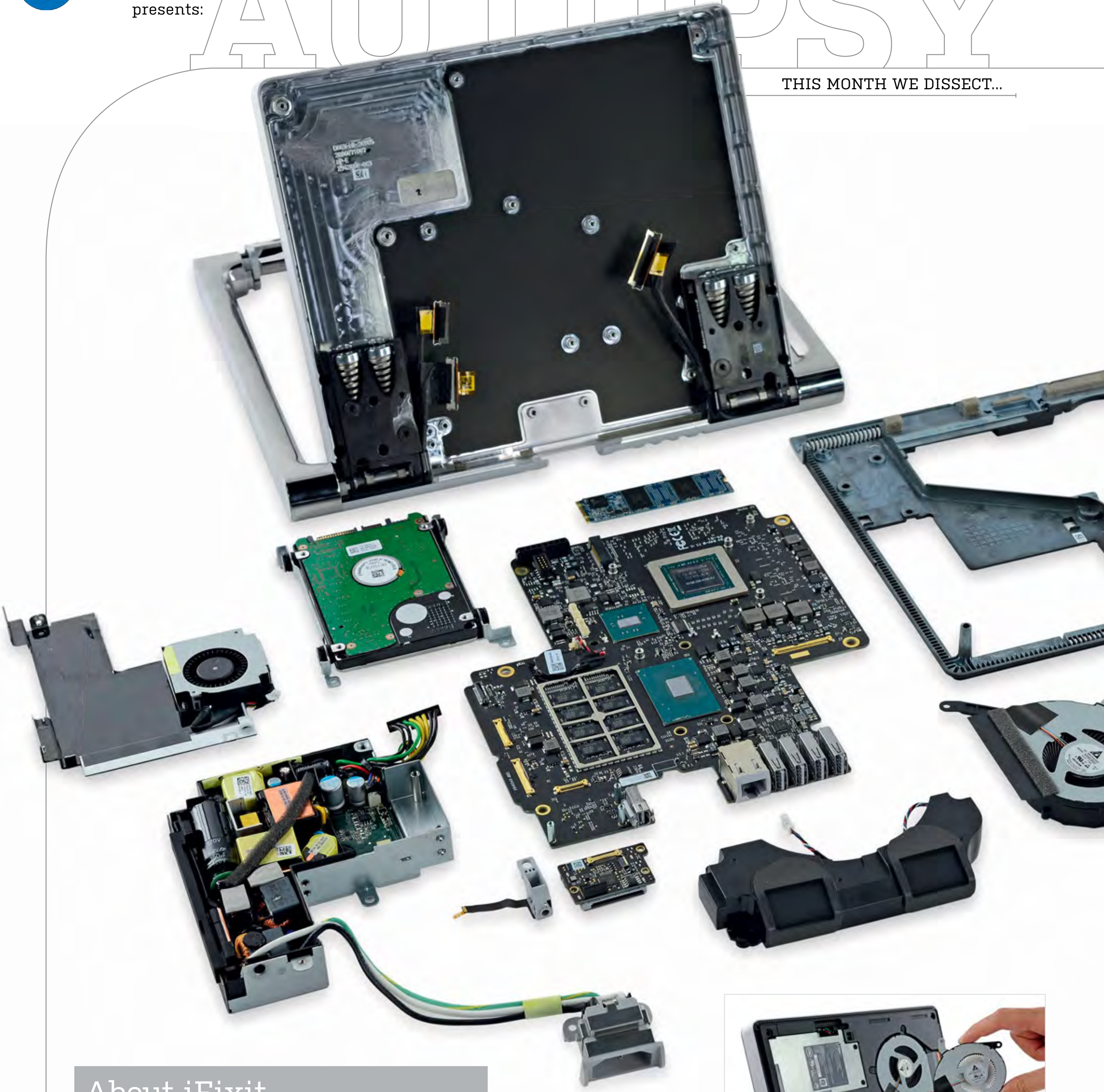
As the motherboard takes time to identify the PCIe drive as a bootable device, it can take 20–60 seconds for a PCIe system to boot. The obvious benefit is when you're on desktop, with near instantaneous program loading and super-fast file transfers, but it's still sluggish from power-on to login. RAID solutions don't help, because the system cycles through the necessary prompts to allow you to enter the RAID UEFI setup each bootup as well, further increasing load times. So, the answer? Well, it sounds ridiculous, but if you're just after a quick booting system, and aren't really a professional just yet, the SSD still might be the best choice for you.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...



One does not simply take apart a Surface Studio.

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Microsoft Surface Studio

Two PCs in one? Almost.

Fortunately, that display is fairly easy to replace if damaged.

BACKGROUND

Good news, everyone! Microsoft has made its first desktop ever. The Surface Studio is big, expensive, powerful, and most importantly, it's on our teardown table. Is this a machine for creative pros, or a me-too entry in the modern wave of fashionably disposable hardware? If it survives this teardown, we'll have our answer.

MAJOR TECH SPECS

- 28-inch adjustable PixelSense display, with 4500x3000 resolution (192 dpi), supporting sRGB, DCI-P3, and Vivid color profiles, plus 10-point multitouch.
- Sixth-generation Intel Core i5 or i7 CPU, with 8GB, 16GB, and 32GB RAM configuration options.
- Nvidia GeForce GTX 965M GPU (paired with 2GB GDDR5), or GTX 980M (paired with 4GB GDDR5).
- 1TB and 2TB hybrid storage options.
- 802.11ac Wi-Fi/Bluetooth 4.0/Xbox Wireless built in.
- Supports Surface Pen and Surface Dial.

KEY FINDINGS

- We tip the Studio on to its back and inspect the base, hoping to find a way in. A strip of air vents borders the bottom panel, and at each corner we find a round rubber foot, concealing a Torx screw. The two on the front corners are of the extra-long variety. As manufacturers continue the fight against visible screws, we're OK with this solution—it's certainly better than gluing the entire thing shut. Screws jettisoned, the heavy bottom cover still holds on by way of several clips. So, we apply a little suction power to yank it free.
- Pulling the back cover off reveals a myriad of components. There's a strict order of operations here. First out are two fans, but they remain anchored by wires with hidden leads. That midframe will have to come out before we can proceed further. As we lift it away, it brings an attached speaker out with it, along with a third wire tethered to the motherboard.
- Finally, we have access to some guts—this Studio is chock-full of 'em. But we need to delve deeper to see if it has the glory. We start with the high-powered half of the hybrid storage: a standard, removable, 64GB SanDisk Z400s M.2 SSD. And on board we find two SanDisk 05466 032G 32GB NAND flash storage modules, and a Silicon Motion SM2246XT SATA III 6Gb/s DRAM-less SSD controller.
- It's time to return to that huge 28-inch glass display. Gulp. Unsure what kind of adhesive lies in wait, we throw down a pair of iOpeners to soften it up. Many swipes of the iMac opening tool later, and we're ready to call this glue the in-between. It's not the overkill tar of the Surface Pro, but it's also not slice-it-down-the-middle clean iMac adhesive. It's in between. A bit of a struggle, but not impossible.
- Repairability Score: 5 out of 10 (10 is easiest to repair). The base is easy to open and home to several modular components—including the standard SATA hard drive and M.2 SSD—that can be replaced without disassembling the display. The entire display assembly can be replaced as a piece, without dismantling the display or the base. The RAM, CPU, and GPU are soldered to the board, and cannot be upgraded. You may want to think twice about that 8GB configuration. A few components embedded in the display (buttons, front sensors, and speakers) would be difficult to replace if they failed.

Connect Securely with OpenVPN

YOU'LL NEED THIS

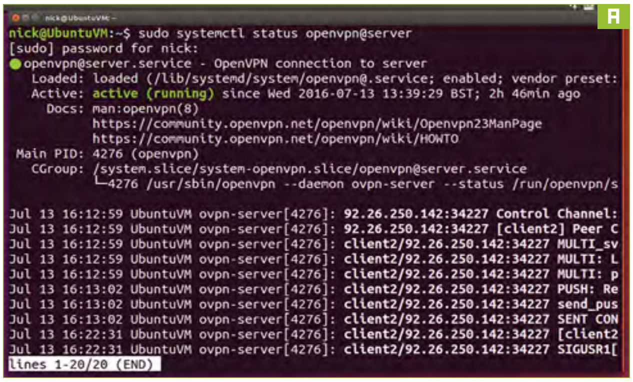
DYNAMIC DNS ADDRESS
Get a free one from NoIP (www.noip.com/free) and point your client at that.

UFW FIREWALL
Visit https://bit.ly/openvpn-ufw for the steps you need to follow to configure it (substitute `nano` for `vim` in the instructions).

JUST HOW SECURE IS YOUR INTERNET CONNECTION? The answer is often "not very." One of the most dangerous places to surf the web or check your email is via a public Wi-Fi hotspot. What you need is a guaranteed form of encryption to keep your business private, and that's where a virtual private network (VPN) comes in.

VPNs are designed to add an extra layer of security to the Internet and other public networks. They basically create a secure "tunnel," inside which all your data is encrypted before being sent over the network. Their main use for home users is to provide a secure connection to the Internet, even over insecure networks. Commercial VPN services offer free packages, but these are slow and limited.

A much better option is to add your own VPN to your Ubuntu computer for free. Thanks to OpenVPN, you can set up your own server, then configure it to provide one or more devices (mobile or computer) with a secure on-demand VPN whenever it's required. Without further ado, then, let's get started. **–NICK PEERS**



```
nick@UbuntuVM:~$ sudo systemctl status openvpn@server
[sudo] password for nick:
● openvpn@server.service - OpenVPN connection to server
   Loaded: loaded (/lib/systemd/system/openvpn@.service; enabled; vendor preset:
   Active: active (running) since Wed 2016-07-13 13:39:29 BST; 2h 46min ago
     Docs: man:openvpn(8)
           https://community.openvpn.net/openvpn/wiki/Openvpn23ManPage
           https://community.openvpn.net/openvpn/wiki/HOWTO
 Main PID: 4276 (openvpn)
   CGroup: /system.slice/system-openvpn.slice/openvpn@server.service
           └─4276 /usr/sbin/openvpn --daemon ovpn-server --status /run/openvpn/s

Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: 92.26.250.142:34227 Control Channel:
Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: 92.26.250.142:34227 [client2] Peer C
Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 MULTI_sv
Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 MULTI: L
Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 MULTI: p
Jul 13 16:13:02 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 PUSH: Re
Jul 13 16:13:02 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 send_pus
Jul 13 16:13:02 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 SENT CON
Jul 13 16:22:31 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 [client2
Jul 13 16:22:31 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 SIGUSR1[
lines 1-20/20 (END)
```

1

GETTING STARTED

The following tutorial works with your basic Ubuntu 16.04 install—the only real requirement is that your PC is on and connected to the Internet at home whenever you want to employ your VPN's services abroad.

» First, let's install OpenVPN Server. Although it's part of the official Ubuntu repositories, you can't install it through Software Center, so open a Terminal window, and type the following:

```
$ sudo apt-get update
$ sudo apt-get install openvpn easy-rsa
```

» This installs two packages—the latter (easy-rsa) sets up and manages the certificates required to encrypt your network traffic. The easy-rsa package allows you to use OpenVPN in a PKI (Public Key Infrastructure), which consists of public and private keys for each server and client, with the public keys being used to identify trusted clients and servers to each other. These public keys are signed using certificates to verify their identity, and your server needs to be configured as a Certificate Authority (CA) to create, distribute, and manage these certificates.

» First job, then, is to set up your CA, and build the server's private and public keys—check out the step-by-step guide opposite for details. Once that process is complete, it's a good idea to "harden" your VPN's security further with the following Terminal commands:

```
$ cd ~/openvpn-ca
$ ./build-dh
$ openvpn --genkey --secret keys/ta.key
```

2

CONFIGURE OPENVPN SERVER

Now it's time for the nitty-gritty: configuring your OpenVPN Server, and getting it up and running. First, you need to copy the encryption keys and other files you've just created to the "/etc/openvpn" directory, again using the Terminal:

THE MAKE_CONFIG.SH SCRIPT

Open up a Terminal, and then type the following command in order to create an empty file:

```
$ nano ~/openvpn-ca/client-configs/make_config.sh
```

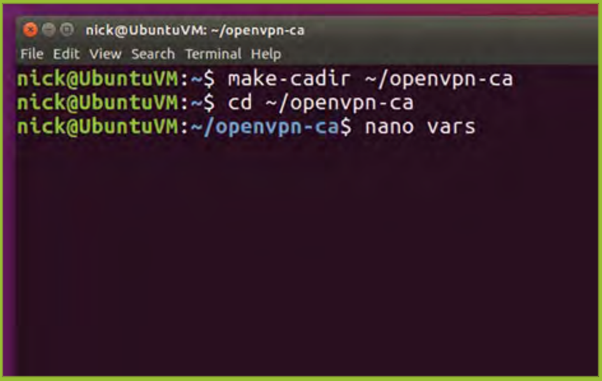
Now you need to carefully enter the following lines:

```
#!/bin/bash
# First argument: Client identifier
KEY_DIR=~/openvpn-ca/keys

OUTPUT_DIR=~/openvpn-ca/client-configs/files
BASE_CONFIG=~/openvpn-ca/client-configs/client.conf

cat ${BASE_CONFIG} \
  <(echo -e '<ca>') \
  ${KEY_DIR}/ca.crt \
  <(echo -e '</ca>\n<cert>') \
  ${KEY_DIR}/${1}.crt \
  <(echo -e '</cert>\n<key>') \
  ${KEY_DIR}/${1}.key \
  <(echo -e '</key>\n<tls-auth>') \
  ${KEY_DIR}/ta.key \
  <(echo -e '</tls-auth>') \
  > ${OUTPUT_DIR}/${1}.ovpn

```

Once created, save and close the file, before typing the following command to make it executable:

```
$ chmod 700 ~/openvpn-ca/client-configs/make_config.sh
```

SET UP YOUR CERTIFICATE AUTHORITY

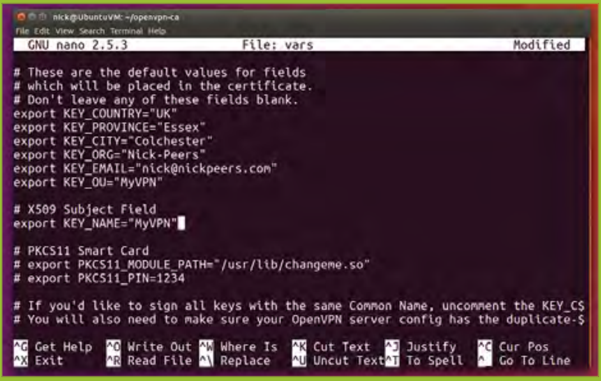

nick@UbuntuVM: ~/openvpn-ca
File Edit View Search Terminal Help

```
nick@UbuntuVM:~$ make-cadir ~/openvpn-ca
nick@UbuntuVM:~$ cd ~/openvpn-ca
nick@UbuntuVM:~/openvpn-ca$ nano vars
```

1. SET UP CERTIFICATE AUTHORITY DIRECTORY

First, you need to copy the easy-rsa template directory to your home directory, so your custom certificates aren't overwritten when the package is updated. So, open the Terminal and type the following:

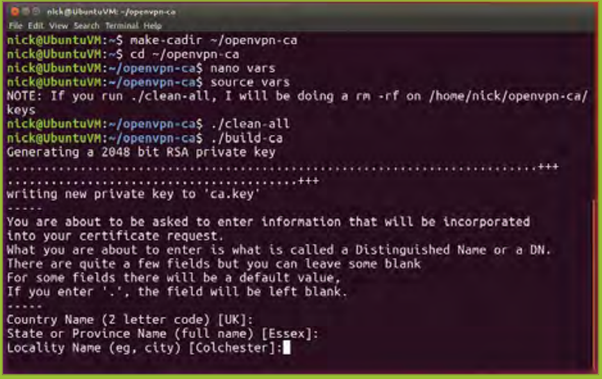
```
$ make-cadir ~/openvpn-ca
$ cd ~/openvpn-ca
$ nano vars
```


nick@UbuntuVM: ~/openvpn-ca
File Edit View Search Terminal Help

```
  GNU nano 2.5.3                 File: vars                            Modified

# These are the default values for fields
# which will be placed in the certificate.
# Don't leave any of these fields blank.
export KEY_COUNTRY="UK"
export KEY_PROVINCE="Essex"
export KEY_CITY="Colchester"
export KEY_ORG="Nick-Peers"
export KEY_EMAIL="nick@nickpeers.com"
export KEY_OU="MyVPN"

# X509 Subject Field
export KEY_NAME="MyVPN"

# PKCS11 Smart Card
# export PKCS11_MODULE_PATH="/usr/lib/changeme.so"
# export PKCS11_PIN=1234

# If you'd like to sign all keys with the same Common Name, uncomment the KEY_C$
# You will also need to make sure your OpenVPN server config has the duplicate-$

^G Get Help   ^O Write Out  ^W Where Is   ^K Cut Text   ^J Justify    ^C Cur Pos
^X Exit       ^R Read File  ^\ Replace    ^U Uncut Text^T To Spell    ^_ Go To Line
```

2. EDIT VARS FILE

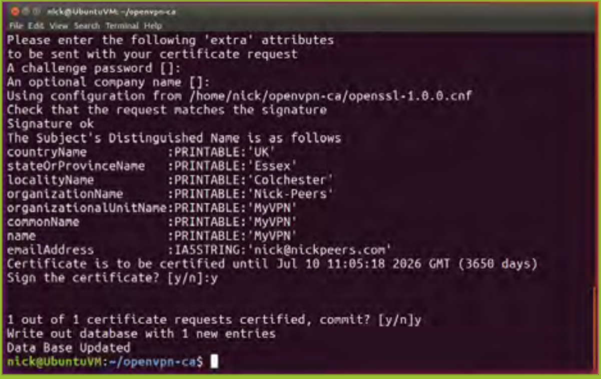
Scroll down to the group of lines beginning "export KEY_COUNTRY," and fill them in with your own personal information—see the screenshot for an example. Note "KEY_PROVINCE" should be filled with the state, such as "Mississippi" or "California." Put your name or organization in "KEY_ORG," and fill "KEY_OU" and "KEY_NAME" with whatever you like, such as "MyVPN." Save the file (Ctrl-O) and exit.


nick@UbuntuVM: ~/openvpn-ca
File Edit View Search Terminal Help

```
nick@UbuntuVM:~$ make-cadir ~/openvpn-ca
nick@UbuntuVM:~$ cd ~/openvpn-ca
nick@UbuntuVM:~/openvpn-ca$ nano vars
nick@UbuntuVM:~/openvpn-ca$ source vars
NOTE: If you run ./clean-all, I will be doing a rm -rf on /home/nick/openvpn-ca/
keys
nick@UbuntuVM:~/openvpn-ca$ ./clean-all
nick@UbuntuVM:~/openvpn-ca$ ./build-ca
Generating a 2048 bit RSA private key
...........................................................................+++
..........................................+++
writing new private key to 'ca.key'
-----
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [UK]:
State or Province Name (full name) [Essex]:
Locality Name (eg, city) [Colchester]:
```

3. BUILD CERTIFICATE AUTHORITY

At the Terminal, verify you're still in the openvpn-ca directory, then type: "source vars" and hit Enter. You should see a "NOTE" appear (see screenshot). Now type "./clean-all" and hit Enter, followed by "./build-ca" and hit Enter. You're taken through the root certificate authority key and certificate. Hit Enter when prompted to confirm each edit you made in the previous step.


nick@UbuntuVM: ~/openvpn-ca
File Edit View Search Terminal Help

```
Please enter the following 'extra' attributes
to be sent with your certificate request
A challenge password []:
An optional company name []:
Using configuration from /home/nick/openvpn-ca/openssl-1.0.0.cnf
Check that the request matches the signature
Signature ok
The Subject's Distinguished Name is as follows
countryName           :PRINTABLE:'UK'
stateOrProvinceName   :PRINTABLE:'Essex'
localityName          :PRINTABLE:'Colchester'
organizationName      :PRINTABLE:'Nick-Peers'
organizationalUnitName:PRINTABLE:'MyVPN'
commonName            :PRINTABLE:'MyVPN'
name                  :PRINTABLE:'MyVPN'
emailAddress          :IA5STRING:'nick@nickpeers.com'
Certificate is to be certified until Jul 10 11:05:18 2026 GMT (3650 days)
Sign the certificate? [y/n]:y


1 out of 1 certificate requests certified, commit? [y/n]y
Write out database with 1 new entries
Data Base Updated
nick@UbuntuVM:~/openvpn-ca$
```

4. GENERATE SERVER'S KEYS

Type "./build-key-server MyVPN" and hit Enter, replacing "MyVPN" with the value you entered for "KEY_NAME" in step 2. Hit Enter to accept the default choices as before. When prompted to create a challenge password, hit Enter to leave it blank, and hit Enter again when prompted for an optional company name. Complete the process by pressing Y to the last two prompts.

```
$ cd ~/openvpn-ca/keys
$ sudo cp ca.crt ca.key MyVPN.crt MyVPN.key ta.key dh2048.pem /etc/openvpn
```

» Replace `MyVPN.crt` and `MyVPN.key` with the value you allocated to `KEY_NAME` in the walkthrough above. Next, you need to generate your OpenVPN configuration file:

```
$ cd /usr/share/doc/openvpn/examples/sample-config-files
$ sudo cp server.conf.gz /etc/openvpn
$ sudo gzip -d /etc/openvpn/server.conf.gz
```

» Now follow the second step-by-step guide (over the page) to configure your server for basic usage. Once done, you need to perform one critical step to allow your clients to actually access the Internet through your VPN. First, enter the following command:

```
$ ip route | grep default
```

» Make a note of the interface listed next to "dev"—on our machine, this is "enp0s3." Now enter the following command, substituting `enp0s3` with the interface listed on your PC, if applicable:

```
$ sudo iptables -t nat -A POSTROUTING -s 10.8.0.0/24 -o enp0s3 -j MASQUERADE
```

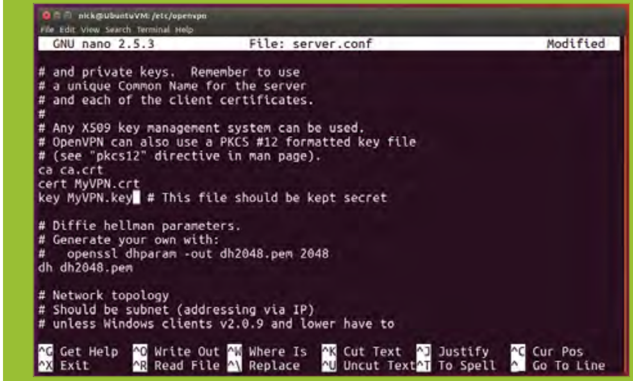
3

START AND TEST YOUR SERVER

It's time to get things up and running. Type the following Terminal command, which launches OpenVPN using the server.conf file you've configured:

```
$ sudo systemctl start openvpn@server
```

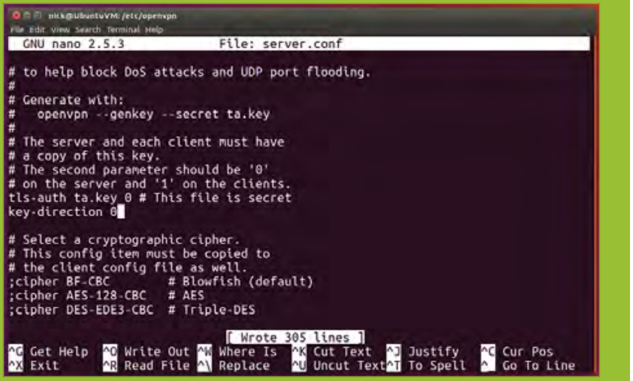
CONFIGURE YOUR SERVER


nick@UbuntuVM: /etc/openvpn
File Edit View Search Terminal Help

```
  GNU nano 2.5.3             File: server.conf                        Modified

# and private keys.  Remember to use
# a unique Common Name for the server
# and each of the client certificates.
#
# Any X509 key management system can be used.
# OpenVPN can also use a PKCS #12 formatted key file
# (see "pkcs12" directive in man page).
ca ca.crt
cert MyVPN.crt
key MyVPN.key # This file should be kept secret

# Diffie hellman parameters.
# Generate your own with:
#   openssl dhparam -out dh2048.pem 2048
dh dh2048.pem

# Network topology
# Should be subnet (addressing via IP)
# unless Windows clients v2.0.9 and lower have to

^G Get Help  ^O Write Out ^W Where Is  ^K Cut Text  ^J Justify   ^C Cur Pos
^X Exit      ^R Read File ^\ Replace   ^U Uncut Text^T To Spell  ^_ Go To Line
```

1. DEFINE SERVER KEYS

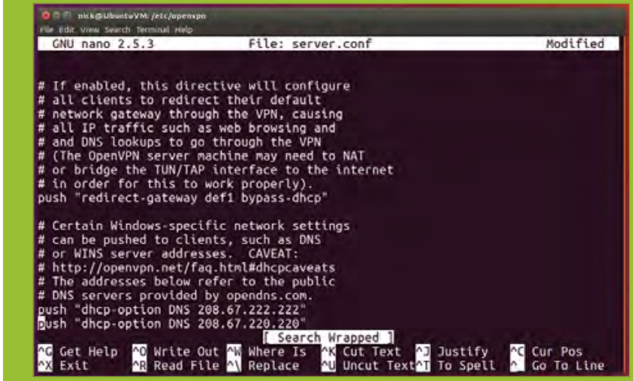
Open the configuration file you've just created using `sudo nano /etc/openvpn/server.conf` at the Terminal. We're going to focus on the bare minimum settings required to get your server up and running. Start by scrolling down to the "# SSL/TLS root certificate…" section, and changing the "cert server.crt" and "key server.key" lines to point to the files you created in step four of the previous walkthrough.


nick@UbuntuVM: /etc/openvpn
File Edit View Search Terminal Help

```
  GNU nano 2.5.3             File: server.conf

# to help block DoS attacks and UDP port flooding.
#
# Generate with:
#   openvpn --genkey --secret ta.key
#
# The server and each client must have
# a copy of this key.
# The second parameter should be '0'
# on the server and '1' on the clients.
tls-auth ta.key 0 # This file is secret
key-direction 0

# Select a cryptographic cipher.
# This config item must be copied to
# the client config file as well.
;cipher BF-CBC        # Blowfish (default)
;cipher AES-128-CBC   # AES
;cipher DES-EDE3-CBC  # Triple-DES

                               [ Wrote 305 lines ]
^G Get Help  ^O Write Out ^W Where Is  ^K Cut Text  ^J Justify   ^C Cur Pos
^X Exit      ^R Read File ^\ Replace   ^U Uncut Text^T To Spell  ^_ Go To Line
```

2. IMPLEMENT EXTRA ENCRYPTION

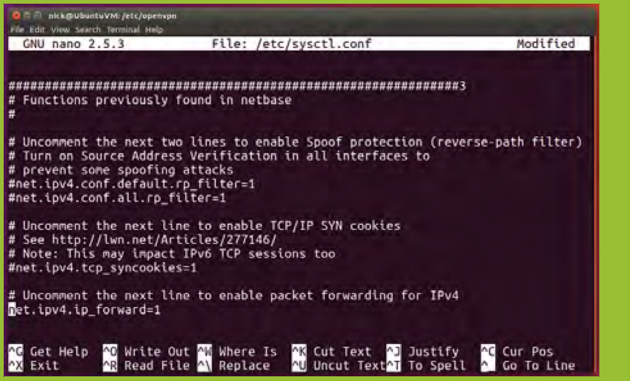
Now press Ctrl-W, and type "tls-auth"—you're taken to a line marked ";tls-auth ta.key 0." Remove the semi-colon from the beginning of this line (a process known as uncommenting) to enable it. Now add the following line underneath it, as shown in the screenshot above: "key-direction 0"—this ensures that the extra TLS authentication that you set up earlier is enabled for OpenVPN.


nick@UbuntuVM: /etc/openvpn
File Edit View Search Terminal Help

```
  GNU nano 2.5.3             File: server.conf                        Modified


# If enabled, this directive will configure
# all clients to redirect their default
# network gateway through the VPN, causing
# all IP traffic such as web browsing and
# and DNS lookups to go through the VPN
# (The OpenVPN server machine may need to NAT
# or bridge the TUN/TAP interface to the internet
# in order for this to work properly).
push "redirect-gateway def1 bypass-dhcp"

# Certain Windows-specific network settings
# can be pushed to clients, such as DNS
# or WINS server addresses.  CAVEAT:
# http://openvpn.net/faq.html#dhcpcaveats
# The addresses below refer to the public
# DNS servers provided by opendns.com.
push "dhcp-option DNS 208.67.222.222"
push "dhcp-option DNS 208.67.220.220"
                                [ Search Wrapped ]
^G Get Help  ^O Write Out ^W Where Is  ^K Cut Text  ^J Justify   ^C Cur Pos
^X Exit      ^R Read File ^\ Replace   ^U Uncut Text^T To Spell  ^_ Go To Line
```

3. CONFIGURE WEB DIRECTION

These next tweaks instruct all connected clients to route their web traffic through the VPN. Press Ctrl-W to locate "redirect-gateway," and uncomment the line it's on: "push…." Uncomment the next two instances of "push" referring to DNS servers, as shown above. Finally, search for "nobody," and uncomment the "user nobody" and "group nogroup" lines. Save and exit.


nick@UbuntuVM: /etc/openvpn
File Edit View Search Terminal Help

```
  GNU nano 2.5.3           File: /etc/sysctl.conf                     Modified


###################################################################3
# Functions previously found in netbase
#

# Uncomment the next two lines to enable Spoof protection (reverse-path filter)
# Turn on Source Address Verification in all interfaces to
# prevent some spoofing attacks
#net.ipv4.conf.default.rp_filter=1
#net.ipv4.conf.all.rp_filter=1

# Uncomment the next line to enable TCP/IP SYN cookies
# See http://lwn.net/Articles/277146/
# Note: This may impact IPv6 TCP sessions too
#net.ipv4.tcp_syncookies=1

# Uncomment the next line to enable packet forwarding for IPv4
net.ipv4.ip_forward=1


^G Get Help  ^O Write Out ^W Where Is  ^K Cut Text  ^J Justify   ^C Cur Pos
^X Exit      ^R Read File ^\ Replace   ^U Uncut Text^T To Spell  ^_ Go To Line
```

4. ENABLE IP FORWARDING

Type `sudo nano /etc/sysctl.conf` and uncomment out the following line by removing the preceding # symbol from it: "#net.ipv4.ip_forward=1." Save and exit, then type the following command to reload sysctl: `sudo sysctl -p`. You should see "net.ipv4 ip_forward =1" appear, indicating the setting has been correctly applied. That's it!

» Now check the server is running correctly:

```
$ sudo systemctl status openvpn@server
```

» You should see a list of messages appear on screeen, including the all-important "active (running)" message [**Image A**], along with "Initialization sequence completed" at the bottom—press Ctrl-C to interrupt the status check. Next, check that the OpenVPN interface is available:

```
$ ip addr show tun0
```

» If it shows a configured interface ending with "valid_lft forever preferred_lft forever," things should be working correctly. You can now configure OpenVPN to launch automatically at startup with the following line:

```
$ sudo systemctl enable openvpn@server
```

4

MAKE CLIENT CONFIGURATION EASY

The simplest way to configure your client is through the use of specially made .ovpn files, inside which the required key files are embedded, along with the settings needed to connect. These are created on your server, and here's what you need to do.

» Create a directory structure inside which your client configuration files are stored, then lock down the directory permissions, and create a base config file to work from:

```
$ mkdir -p ~/openvpn-ca/client-configs/files
$ chmod 700 ~/openvpn-ca/client-configs/files
```

» Now open the Nautilus file manager, click the "Computer" link on the left, and browse to /usr/share/

SET UP YOUR CLIENT

You can access your OpenVPN server through a variety of platforms—there's an official client for Windows, Android, and iOS (visit www.openvpn.net for details), while MacOS users can use Tunnelblick (www.tunnelblick.net). Transferring the .opvn configuration file varies from device to device: you can simply copy the file to C:\Program Files\OpenVPN\config in Windows, for example, or double-click it to import it into Tunnelblick on MacOS.

If you're running an Ubuntu client, you can install some additional packages and manage your connection through the GUI-friendly Network Manager. Open Terminal and type the following:

```
$ sudo apt-get update
$ sudo apt-get install network-manager-openvpn-gnome
```

Once installed, open the Network Manager from the menu bar, select "Edit Connections," then click "Add." Choose "Import a saved VPN configuration..." from the drop-down menu, and click "Create." Select your .ovpn file, and click "Open," then verify the settings are correct across the four tabs (click "Advanced → TLS Authentication tab" to confirm it's also recognized the TLS key). Give your connection a more suitable name—the name you assigned your VPN under KEY_NAME, say—and click "Save."

Once done, connect through the Network Manager's VPN submenu—you should see a lock appear over the menu bar's icon, indicating the connection has successfully been made. The final step is to open your browser to verify the connection works.

doc/openvpn/examples/sample-config-files/. Copy the client.conf file from here to ~/openvpn-ca/client-configs. Double-click the copied file to edit it in gedit [**Image B**]. First, locate the line marked `remote my-server-1 1194`, and change this to point toward your server's public IP address or dynamic DNS name—for example, `remote 1.2.3.4 1194` or `remote dynamic.ddns.net 1194`.

» Next, uncomment both `;user nobody` and `;group nogroup`, before commenting out the lines `ca ca.crt`, `cert client.crt`, and `key client.key`, because they're added by the batch file. Last, but not least, add the following line beneath `;tls-auth ta.key 1` (which should remain commented out): `key-direction 1`. Save and exit, then follow the instructions in the box on page 58 to create the make_config.sh file, which you'll use to generate the client configuration files whenever they're needed for each client.

5 GENERATE A CLIENT CONFIGURATION FILE

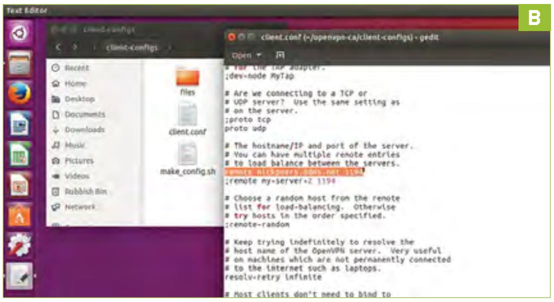
You've now got all the tools you need to create your client configuration files. Here's the process you need to follow in order to build them. First, you need to generate a certificate and key for your client using the following two commands:

```
$ cd ~/openvpn-ca && source vars
```

» This time, ignore the note—we don't want to clean anything—and then type:

```
$ ./build-key client1
```

» You need a unique name for each client certificate you generate—so, for subsequent certificates, you would use `client2`, `client3`, and so on. Again, you're taken through a similar process as when you ran the build-server-key command, and the answers are exactly the same—no challenge password, and accepting the default choices.



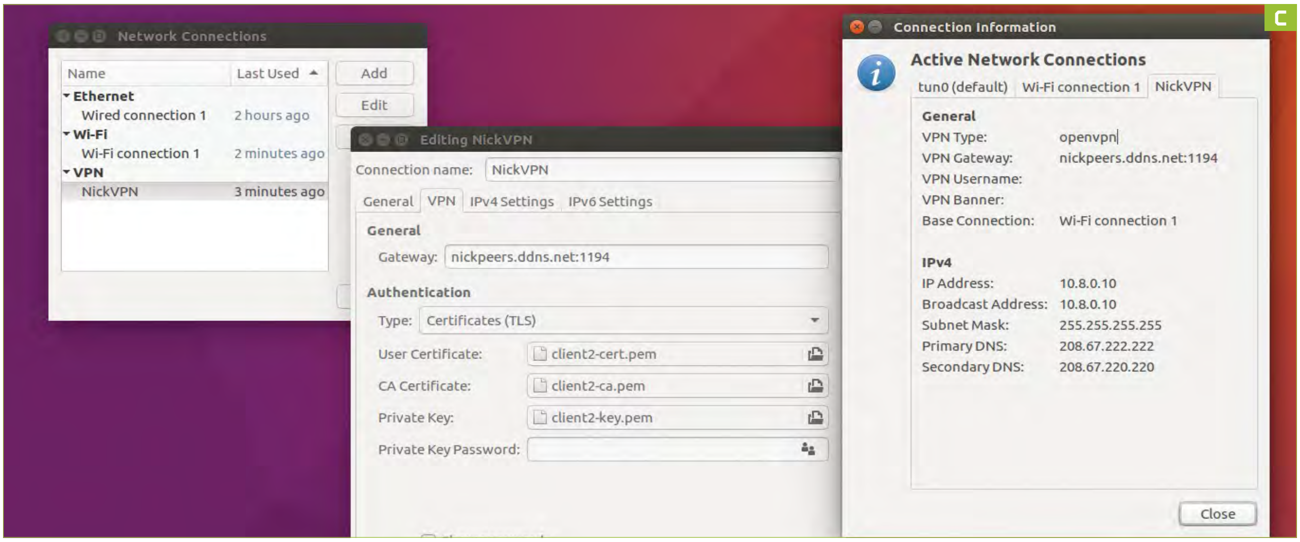
client.conf (~/openvpn-ca/client-configs) - gedit

```
# for the TAP adapter.
;dev-node MyTap

# Are we connecting to a TCP or
# UDP server?  Use the same setting as
# on the server.
;proto tcp
proto udp

# The hostname/IP and port of the server.
# You can have multiple remote entries
# to load balance between the servers.
remote nickpeers.ddns.net 1194
;remote my-server-2 1194

# Choose a random host from the remote
# list for load-balancing.  Otherwise
# try hosts in the order specified.
;remote-random

# Keep trying indefinitely to resolve the
# host name of the OpenVPN server.  Very useful
# on machines which are not permanently connected
# to the internet such as laptops.
resolv-retry infinite

# Most clients don't need to bind to
```

» Once generated, build the configuration file:

```
$ cd client-configs
$ ./make_config.sh client1
```

» You'll find a file marked client1.ovpn inside the client-configs/files subfolder. This now needs to be securely transferred to your client—the box above reveals the different options available to you, and how to configure a VPN connection to your server from another Ubuntu PC. Congratulations—you've just made your Internet connection more secure [**Image C**]. ⏻



Network Connections

Name	Last Used
Ethernet	
Wired connection 1	2 hours ago
Wi-Fi	
Wi-Fi connection 1	2 minutes ago
VPN	
NickVPN	3 minutes ago

Editing NickVPN

Connection name: NickVPN

General | VPN | IPv4 Settings | IPv6 Settings

General

Gateway: nickpeers.ddns.net:1194

Authentication

Type: Certificates (TLS)
User Certificate: client2-cert.pem
CA Certificate: client2-ca.pem
Private Key: client2-key.pem
Private Key Password:

Connection Information

Active Network Connections

tun0 (default) | Wi-Fi connection 1 | NickVPN

General

VPN Type: openvpn
VPN Gateway: nickpeers.ddns.net:1194
VPN Username:
VPN Banner:
Base Connection: Wi-Fi connection 1

IPv4

IP Address: 10.8.0.10
Broadcast Address: 10.8.0.10
Subnet Mask: 255.255.255.255
Primary DNS: 208.67.222.222
Secondary DNS: 208.67.220.220

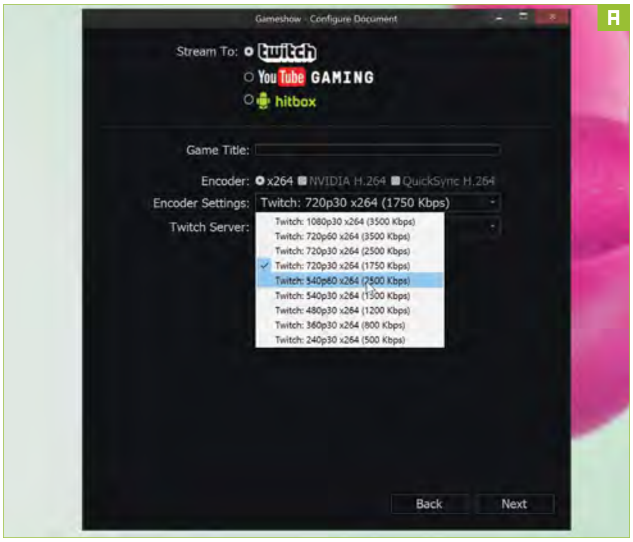
Create Pro Streams with Gameshow

YOU'LL NEED THIS

GAMESHOW
Download and try it for free from www.gameshow.net.

STREAMING ACCOUNT
Head to www.twitch.tv to sign up as a streamer.

THE STREAMING MARKET on YouTube, Twitch, Hitbox, et al is growing quickly. So quickly, in fact, that if you're not putting out a professional-looking stream, you may struggle to gain any viewers at all. This is easier said than done. Open Broadcaster Software certainly gives you the flexibility to produce a fully custom stream, but it's among the most ugly and finicky pieces of software ever created. XSplit provides a beautiful overlay and a similarly beautiful interface, but a subscription involves a not-insignificant outlay. The solution? Streaming's new kid on the block, Gameshow. It's only been around for just over a year, but the fact that it was spawned from the labs of streaming expert TeleStream makes it the perfect tool to add a professional shine to your streams. It's not free, unlike OBS, but there's a limited-resolution or watermarked trial to use to see if you like it, and the full version involves just a $29, one-time outlay for 12 months of updates. **–ALEX COX**



Stream To: ● Twitch ○ YouTube Gaming ○ hitbox
Game Title:
Encoder: ● x264 ■ NVIDIA H.264 ■ QuickSync H.264
Encoder Settings: Twitch: 720p30 x264 (1750 Kbps)
Twitch Server:

- Twitch: 1080p30 x264 (3500 Kbps)
- Twitch: 720p60 x264 (3500 Kbps)
- Twitch: 720p30 x264 (2500 Kbps)
- ✓ Twitch: 720p30 x264 (1750 Kbps)
- Twitch: 540p60 x264 (2500 Kbps)
- Twitch: 540p30 x264 (1500 Kbps)
- Twitch: 480p30 x264 (1200 Kbps)
- Twitch: 360p30 x264 (800 Kbps)
- Twitch: 240p30 x264 (500 Kbps)

1 STARTER'S ORDERS

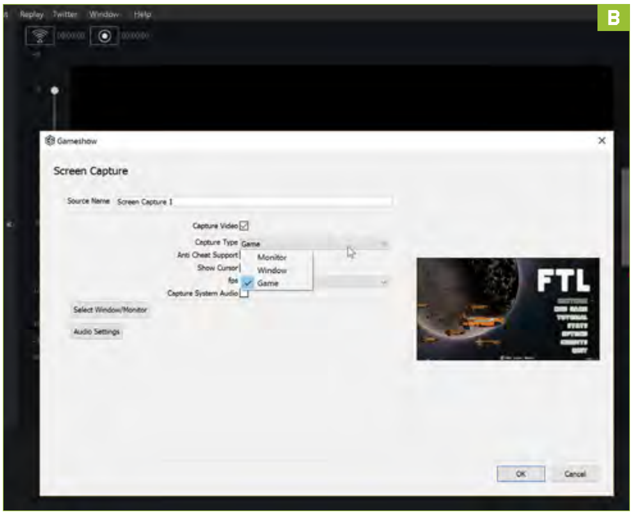
Let's start from the very beginning. Download Gameshow, install it, and run it. Skip past the release notes window, and you're given your most basic creation options. You could, if you're playing a popular game, opt for a template related to the likes of *CS:GO* or *Dota 2,* or choose one of Gameshow's pre-built generic templates, but don't. Although we're in this for an easier time, that's not going to teach you anything, and it certainly won't make your stream unique. Instead, select "Blank," then click "Next." Now click the radio button for the service you'll be streaming to, type in the title of the game you'll be streaming, and, if you have a discrete graphics card, change up the encoder from the basic x264 software encoder to something with a bit more muscle.

›› Users of the free version are stuck with a large animated watermark overlaid over any stream of 30fps 720p at 1,750Kbps or more, so drop the encoder settings down [**Image A**], unless that's something you really want, or you are a paid-up user. Streamers to anything other than YouTube should also pick the most local server here. Hit "Next," and you're asked to authorize with your streaming service of choice, which only happens on your initial setup; you won't be asked again if you create a new template in future. Just like that, you're in—and doesn't Gameshow's dark exterior look intimidating? It does. But it's a puppy inside.

2 GET THE SHOT

Let's give you a quick primer. Gameshow uses three base components to create a streaming template: shots, layers, and, er, shot layers. Shots hold your delicately composed picture elements—your webcam, game, explanation text, and the like. Because they can be reordered in any manner you choose, these elements are called shot layers. Plain ol' layers, on the other hand, enable you to slather several fully composed shots on top of one another. If you create, say, a stream overlay shot in the top layer, with your branding smeared all over it, and put a nice background shot in the bottom layer, you can easily flick through several shots on the middle layer without affecting these in the slightest.

›› We'll start by creating the most basic of shots. So, fire up a game—absolutely any game will work for this—and make sure that it's running, ideally in a window or on a second monitor, so you can still see Gameshow. You'll see, in the bottom portion of Gameshow's main interface, that you have one blank shot at the moment, in the middle layer. This should be highlighted, and it's the one you're about to make changes to. In the left-hand column, click the plus button, then click "Screen capture" to tell Gameshow you want to capture something. This is a slight

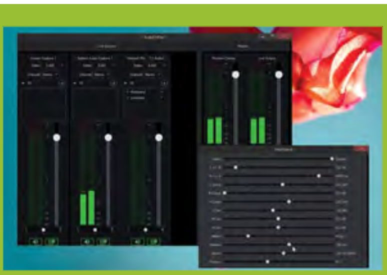


Source Name: Screen Capture 1
Capture Video ☑
Capture Type: Game
Anti Cheat Support
Show Cursor
fps
Capture System Audio ☐

SOUND ADVICE

Great sound is absolutely critical for online streaming—some say even more so than a great picture. While Gameshow's primary focus is on making awesome-looking streams, it's adept at improving your audio, too. Your individual shot layers can be muted or unmuted by clicking the speaker icon next to them, or you can click a shot layer, then hit the speaker icon above, to alter individual volumes and pans. Clicking the headphone icon below any of the vertical meters enables you to monitor what sounds are coming out (useful for checking your mic before you stream), and you have access to quick volume controls if anything starts to hit the red.

The meat of Gameshow's audio tweaks, though, are found in the Audio Mixer, which you can bring up by hitting Ctrl-U. Activate a shot with, say, your microphone in it, and that element appears here. You can then add various equalizing and boosting effects, or alter the balance of your audio to ensure you can be heard over your blaring game.



misnomer, because this option enables you to capture a full screen, a window, or—as you're now able to do by changing the capture type appropriately—a game. Click "Select Window/Monitor," deselect "Capture any full screen game," then select your game's process in the upper drop-down box. Hit "OK," and the game's content, minus any ugly window borders, should appear in the preview window [**Image B**]. Hit "OK" once more, and your game now appears front-and-center in your shot.

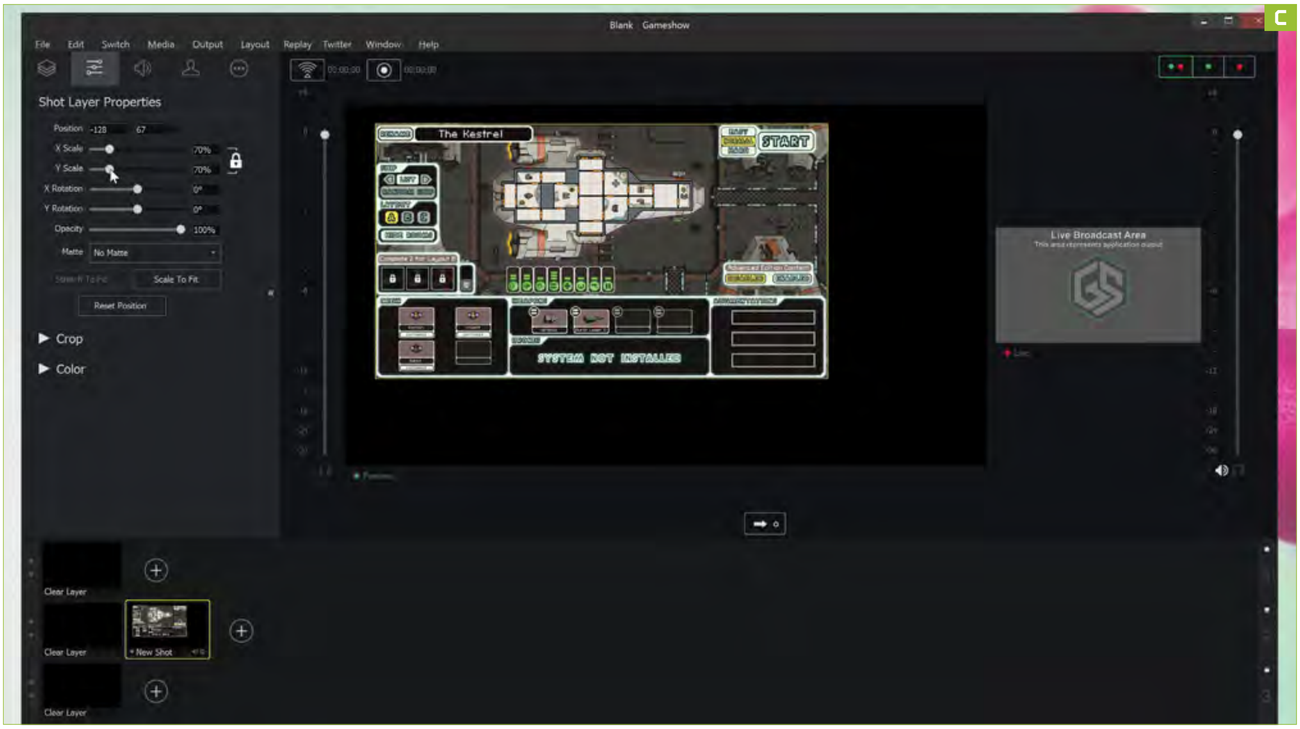
3 FACE TIME

What streamer worth their salt would omit a good old facecam from proceedings? Presuming you've got a webcam hooked up and pointing at your visage, this is a trivial matter: Just add a new element to your shot as before, but this time select "Capture devices," and then your webcam. Here's where things get a bit more tricky, though. For one, that camera is now going to be obscuring some of the game. And if you're anything like us, it's also going to be capturing the strewn detritus of a particularly disorganized office. Time to make use of Gameshow's Properties panel to set things right. First, click your game capture layer in the left column, then click the slider icon above. Dragging the scale sliders [**Image C**] enables you to resize the game to your liking, and you can click and drag it in the central shot composition window to place it exactly where you want it.

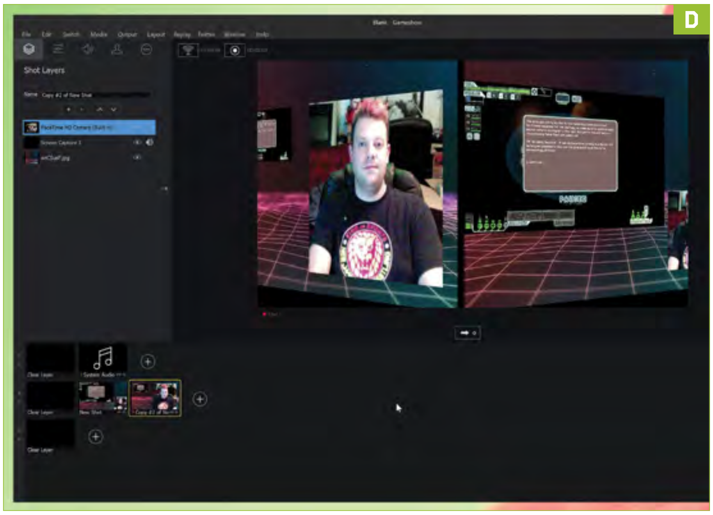
›› Now head back to the shot layers section, and select your webcam. Back in the Properties panel, scroll to the bottom, and expand the Crop menu. You can use these sliders to trim away the abandoned chip bags and dirty plates, and then resize and reposition your webcam as you did before.

4 ALL THE ELEMENTS

If you were to start your stream now (by clicking the broadcast icon, at the top-left of the shot composition window), your viewers wouldn't get a very good show. In fact, they would see what's currently in the live view on the right-hand side—a boring gray screen. This is down to the way Gameshow handles its output; you can compose shots and make tweaks on the fly, but a shot, or any changes you've made to it, aren't (by default) broadcast until you explicitly make it so by selecting it and hitting the Space bar. This is super-handy for maintaining



Shot Layer Properties
Position -128 67
X Scale 70%
Y Scale 70%
X Rotation 0°
Y Rotation 0°
Opacity 100%
Matte No Matte



D

a professional appearance, but something you'll have to remember to do as you stream.

» Even if your shot had gone live, your viewers still wouldn't be getting a very good show, as you're broadcasting with no audio. You can add different audio sources to different shots, but this is a good opportunity to make use of a layer to ensure your system audio is audible, no matter what shot is live. In the uppermost layer, click the plus button to create a new shot, and select "Capture Devices → System Audio Capture." Bear in mind this grabs any sound your machine makes, not just that of the game, which is perfect if you want to involve chums on Discord or Skype, but less neat if Windows 10 is going to shout at you with repeated noisy pop-ups, so make sure your Windows notifications are all switched off. You also have no microphone audio at this point. We'll leave adding this particular shot layer as a little exercise for you—if you're going to create, for example, a BRB shot, you may wish to add it to individual shots on the central layer, rather than having it active at all times.

5 SHOT FOR SHOT

Gameshow is adept at transitioning between different shots, so let's try that now. Right-click your shot in the lower portion of the interface, and select "Duplicate shot." Change the copy by using the shot layer properties controls to make your webcam bigger and your game smaller, then hit the red dot button at the top-right of the Gameshow window to see only the live view. Switch to your new shot by highlighting it and hitting Space, and you'll see the components smoothly resize themselves; switch back using the same process, and you'll see the opposite happen.

» You can create more complex transitions between shots using the Switch menu on the main menu bar. Select your choice of an immediate cut, a smooth transition (which is what we've been using so far), or one of a number of fancy dissolves and wipes [**Image D**]. Note the "Go" option at the top of the menu—using Space still pulls off the old smooth transition; if you want to use your new one, either select "Go," or hit Ctrl-G. Alternatively, and this basically does away with the "compose your shot before it goes live" deal, you can switch on AutoLive in the Switch menu, which changes shots, using your fancy transition, as soon as you click on them. If you're going to use this, make sure you've planned out your stream, and composed all the shots you need, before going live.

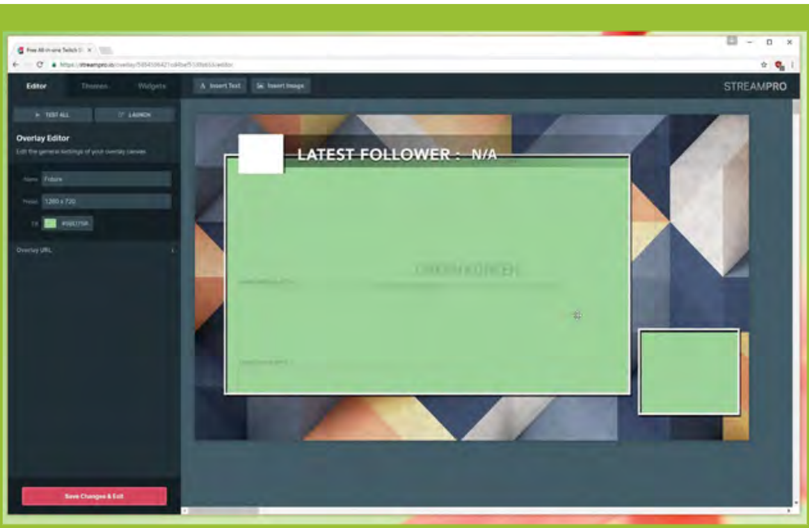
6 STREAM AWAY

Now would be a good time to test your stream, and the only way you can really do this is by going live. There's a broadcast icon at the top-left of the preview window; click this, and you start sending your stream to the Internet. Keep an eye on the stats that now pop up. They let you know the bitrate you're broadcasting at, the amount of CPU power your stream is draining, the number of viewers your stream currently has, and, importantly, the number of frames you've dropped. If you start dropping a lot of

MORE ELEMENTS

You can add just about anything to your Gameshow streams. We've discussed media files, a category that covers images, videos, and audio. Then there are screen captures, encapsulating windows, monitors, and games. You can also add text boxes, either static or drawn from an RSS feed, and make them scroll if you wish. You can pull in your Twitch chat, giving your viewers a chance to see their carefully chosen words (or hastily typed Kappas) on the stream itself. There's a social media widget, which is a quick way to publicize your social feeds, as well as a live Twitter layer, which compiles your latest tweets. You can even run donation drives, as long as you're signed up with imraising.tv and have an API key.

If your desired layer isn't in the long list of included options, it could be time for a little improvisation on your part. Twitch users, for instance, should head over to www.streampro.io and link their Twitch account to the StreamPro service. You can then create your very own custom overlay, and include a whole host of live information. Copy its overlay URL, then go back to Gameshow, and add a new "web display" shot layer, pasting the URL into the appropriate box to see your chosen design pasted on top of your regular stream.



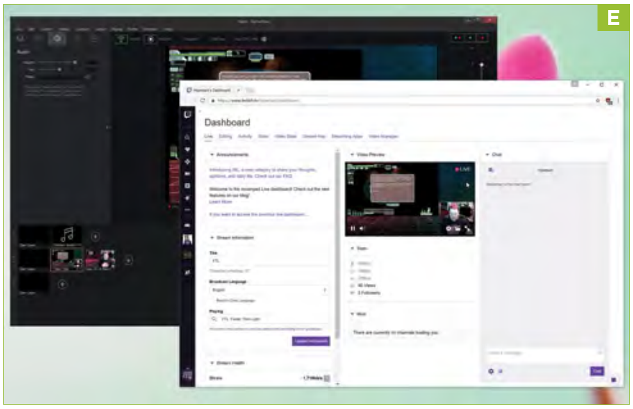
frames, look for potential issues with your Internet connection, or drop your bitrate ("Output → Output Settings") to the point where your broadband connection can handle it properly.

» While you're streaming, it's a good idea to keep an eye on your Twitch (or YouTube, or Hitbox) dashboard [**Image E**], reachable via the Output menu, to ensure you've titled your video correctly, and to keep an eye on chat. Professionalism in presentation is one thing, but you need a keen eye on your audience if you want to keep them coming back. As we're only testing, though, it may be a good idea to cast an eye over your stream to make sure everything's coming out as you expect. Listen to the audio—if there are problems, follow the steps in the "Sound Advice" box, pg. 63, to fix them. Watch the video, and check your transitions—this is where you'll understand exactly what you're doing wrong.

7 ADDING FLOURISHES

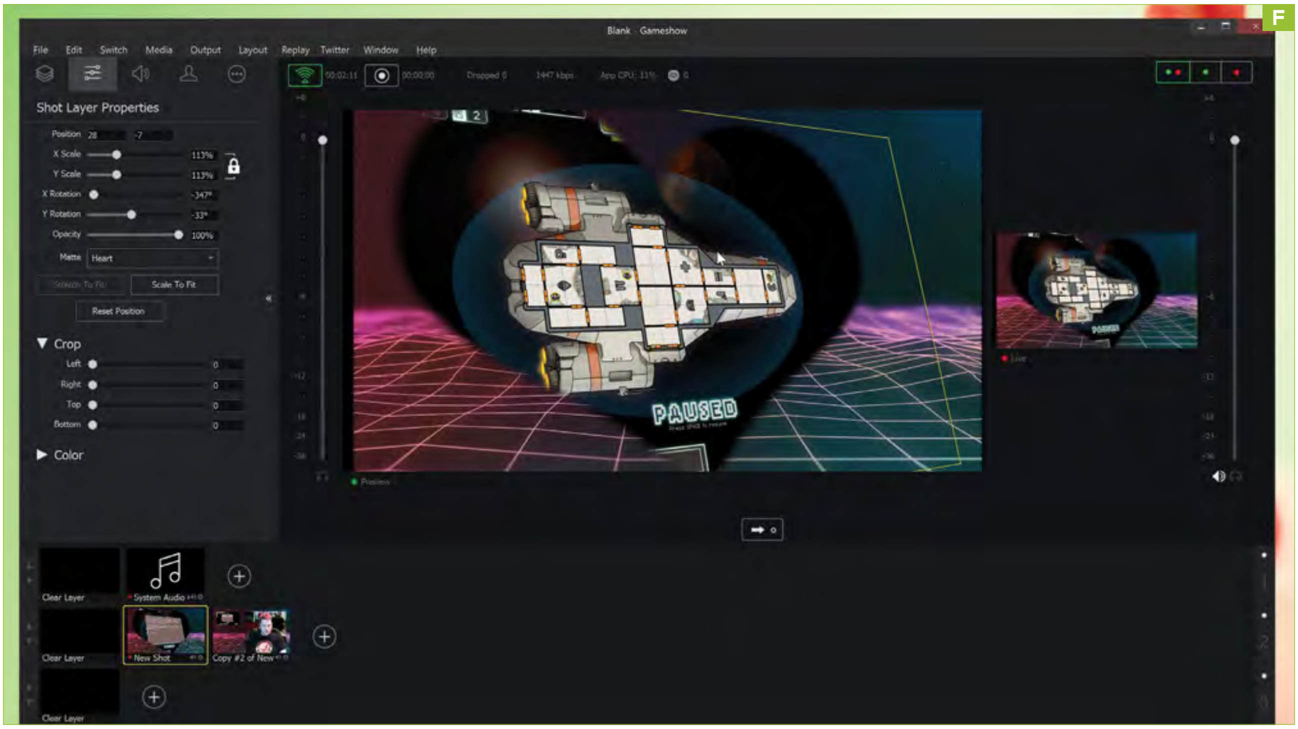
With a test stream out of the way, now's the time to start delving further into Gameshow's features to see what else you can do. Visual shot layers—game capture, webcams, any videos you might have added in—can be manipulated beyond scaling and cropping. Try tweaking the X and Y rotation to put these elements on a wacky angle, for instance. This isn't recommended for the main focus of your footage, but might be a nice effect for your webcam. You can also add mattes, trimming or blurring the edges of your shot layers, and while the built-in options aren't particularly good—unless you want your game surrounded by a cartoon heart [**Image F**] or a silly spiky edge—you can import your own images as custom mattes.

» The more pallid among us may wish to tweak the color options, too. Boosting the saturation and contrast can make a big difference to the output of poor webcams, and there's a handy reset button if you happen to leave yourself looking like a diseased alien. If you're lucky enough to be sitting in front of a brightly colored background, you can also use Gameshow's built-in chroma key options to mask it out altogether. Click the head-and-shoulders icon to bring them up, switch chroma key on with the appropriate checkbox, check the box that lets you pick the key color, and click in your preview to isolate your background. There may be a fair amount of slider tweaking required before you get brilliant results, and bear in mind that this is chroma key, rather than color key, which means it can only remove bright colors, not whites or blacks.



8 FINISHING TOUCHES

You're pretty much familiar with the basics of Gameshow now, so let's go about tidying up your stream layout with a final spit and polish. Add in a background on the bottommost layer (to go behind your game and webcam) by creating a 16:9 image in your favorite arty program, and adding a new "media file" shot layer. Now create yourself a BRB shot in the uppermost layer, for when you're away from your PC, or getting your stream set up. Create a new shot (ideally, this time, without your system audio or microphone input attached), add an image by adding a media file as before, and—hey, why not?—add some royalty-free music, too. It's added in the same way as you would add an image, and is set to automatically loop while the shot is active. Happy streaming! ⏻



Position 28 -7
X Scale 113%
Y Scale 113%
X Rotation -347°
Y Rotation -33°
Opacity 100%
Matte Heart
Left 0
Right 0
Top 0
Bottom 0

Create Your Own Comic Book Panel

YOU'LL NEED THIS

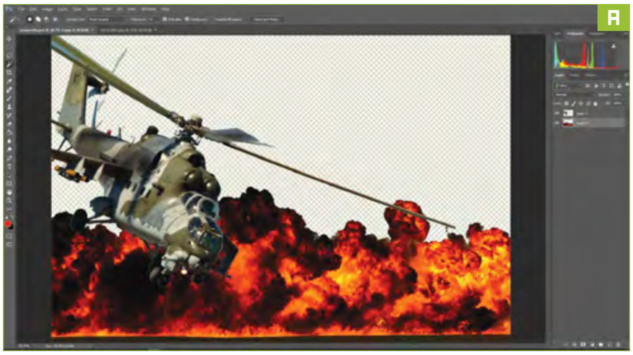
PHOTOSHOP OR ELEMENTS
Available from www.adobe.com.

SOME SOURCE PHOTOS
You might find what you want online, or take your own.

The hand-drawing of comic book panels is a beautiful and time-consuming process that can create great works of art, and it's one in which the medium—generally cheap paper—and the formatting of the pages are part of the overall form, meaning the comic-book "look" is immediately recognizable.

It's not a new medium, either. Comic books date back to at least 1842 in the United States, with the publication of *The Adventures of Obadiah Oldbuck*, a story told through a series of illustrations, each with a caption. American comics entered a "golden age" in 1938, with the launch of *Superman*. Meanwhile, Japan was printing books of illustrated short stories as long ago as the 1700s, which have developed into the enormous media franchises of today's manga. It's the American look we're going to try to recreate here.

Creating comic book panels from photos is, frankly, cheating, but when you haven't got the time or the talent to go to the trouble of penciling, inking, coloring, and lettering, you can create a similar effect in Photoshop. –IAN EVENDEN

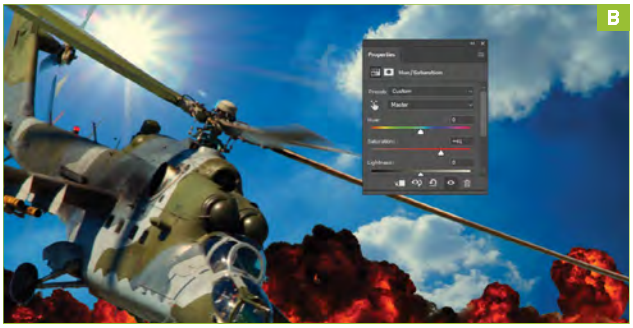


1 GET SOURCE IMAGES READY

Get an idea in your head of what you want your finished panel to look like. We like helicopters and explosions, but if you want to do something involving androgynous young men and their feelings, that's OK, too. Find some source images, either taking them yourself or picking public domain photos from the Internet. We've roughly composited three photos into one image using the Magic Wand tool to select and remove the sky behind the helicopter and on top of the explosion, then dropping a blue sky into the background, and using Free Transform to stretch it to fit [**Image A**].

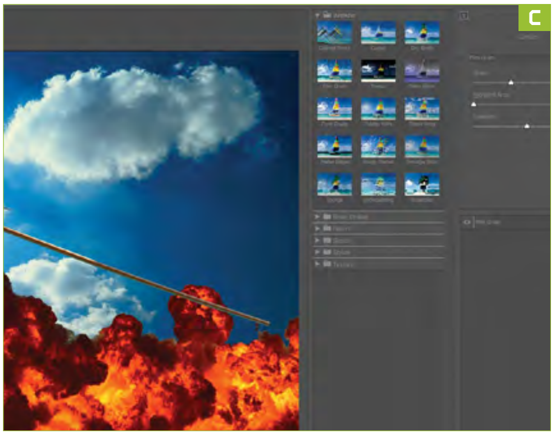
2 USE LAYERS

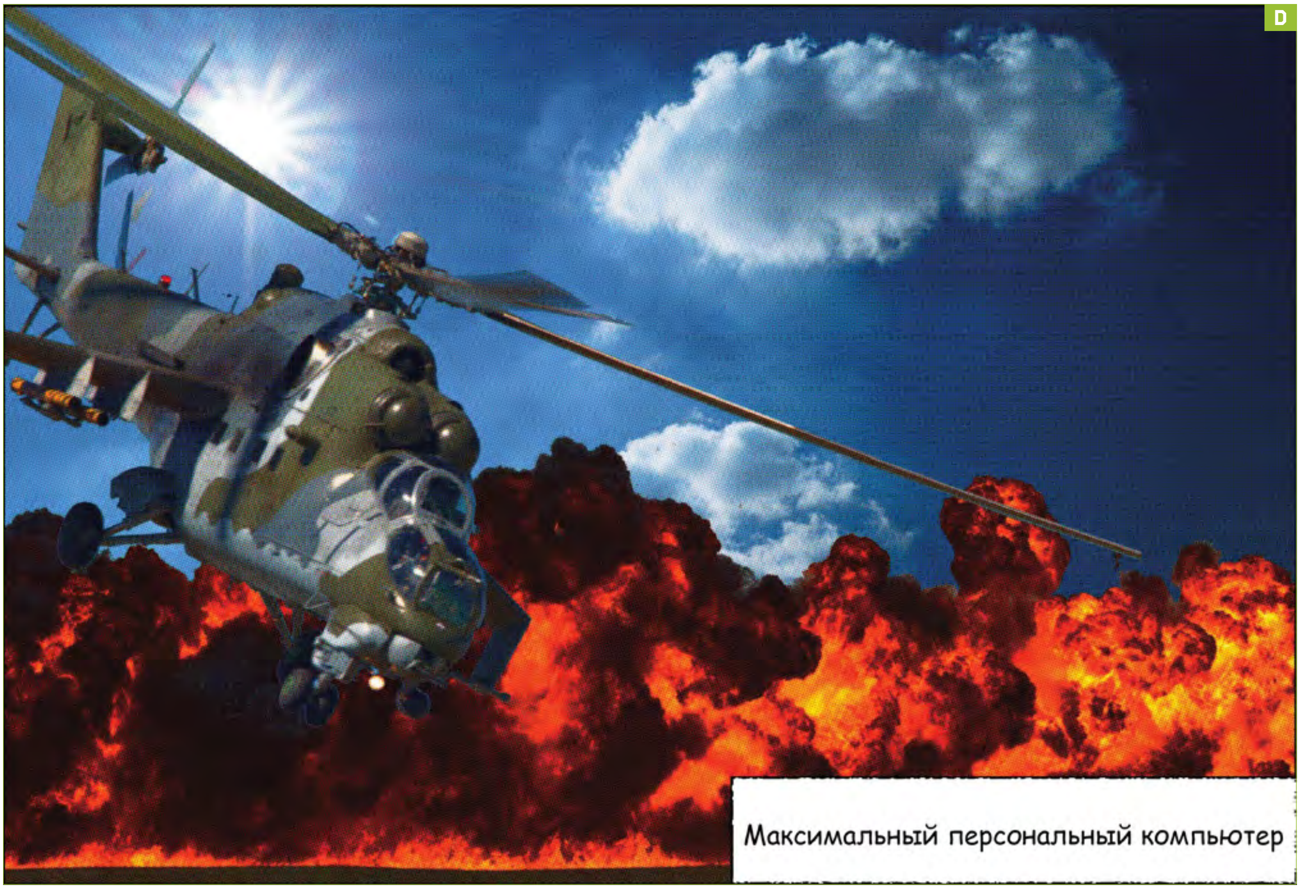
The bright colors of a comic book panel are instantly recognizable, so to begin with, we can increase the saturation of our image a bit. Place a Hue/Saturation Adjustment layer on top of your layer stack by going to "Layer → New Adjustment Layer → Hue/Saturation" [**Image B**]. Using an Adjustment layer means you don't need to flatten your existing layers into one, as the Adjustment layer affects every layer below it in the stack. You can move it up and down the Layers palette to change how many layers it affects. Make sure your elements are in the right positions, as you're about to flatten the image. Perhaps create a new Snapshot in the History palette, so you can come back to this point in the future if you're not happy. Head to "Layer → Flatten Image."



3 ADD A COMIC BOOK EFFECT

Now we're going to apply the comic book effect. Cheap, poor-quality paper—completely unlike the thick, smooth paperstock this magazine is printed on—is a hallmark of comic-book publishing. The books were often marketed at children, and meant to be thrown away at the end of each week, so why bother with quality materials? The way the ink soaks into the paper is part of what gives comic books their distinctive look. We're going to add a little grain to our image, so open the Filter Gallery ("Filter → Filter Gallery") and choose "Film Grain" under "Artistic" [**Image C**]. We've gone for Grain: 7, Highlight Area: 0, Intensity: 5, but the settings will vary depending on the source images you've used. Once it looks good, hit "OK."





4 APPLY THE COLOR HALFTONE FILTER

As you flattened earlier, the only layer you have is a Background. Double-click this to make it Layer 0, then duplicate it by right-clicking it, and selecting the appropriate option from the menu that appears. We're going to add the halftone effect to the top layer, to make our image look as though it was printed using a series of dots, varying in size or spacing, to represent the transitions between colors. There's a simple filter for this: "Filter → Pixelate → Color Halftone." We chose a setting of 6 for "Max Radius," and left the other settings alone. The "Screen Angles" represent the way different colors' screens would be rotated relative to one another in the printing process, to minimize the effects of moire patterns and other distracting visual flaws. Annoyingly, there's no "Preview" checkbox on this filter, so the only way to experiment is to hit the "OK" button, and be ready with Ctrl-Z if you don't like the effect. Remember, selecting the filter name that appears at the top of the "Filter" menu reapplies it with the same settings it was last used at, so you have to select it from the "Pixelate" submenu to run the filter again with different settings. The next step changes the look of the image, so it might be worth changing your mind only after you've seen the result.

5 BRING SOME DETAIL BACK

With your top, halftoned layer selected, change its blend mode to "Darken" using the drop-down menu on the Layers palette. This makes the effect of the Halftone filter less obvious, and puts back a little of the detail that was lost when the filter was applied.

6 FINISHING TOUCHES

If you're happy with the result, add a few more comic book touches, such as a black outline, by selecting the whole composition with Ctrl-A, then going to "Edit → Stroke," and stroking a black line around the inside of the selection rectangle's edges. If you want to add a caption, draw a rectangle in one of the corners, and stroke its edges with black, but this time fill it with white or yellow, and simulate a hand-drawn border by using the Ocean Ripple filter ("Filter Gallery → Distort → Ocean Ripple") set to "Large Waves." Add your text in a suitable font—Comic Sans if you must, but other fonts are available online that are free for personal use—then save your image, flatten it, and export it as a jpeg for sharing or printing [**Image D**].

SCREEN PRINTING

This ancient form of printing originated in China a thousand years ago, helped by the fact that silk was readily available to make the mesh for the ink to pass through. Nowadays, silk screen printing is used for high-cost, low-repetition print jobs by those who like to carry out the process by hand—such as Andy Warhol, who used the process for the garish colors of his Marilyn Diptych. Its legacy lives on in the dots used to make up the images in almost all printed material, expanding the model to four different colored inks through four different meshes to create full color.

BUILD IT

ZAK STOREY, REVIEWS EDITOR

The *Maximum PC* Test Bench

Allow us to introduce the machine we'll be using to test hardware over the coming year

LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

EVERY ISSUE, WE DISSECT a plethora of hardware for your reading pleasure. It could be anything from headsets to processors, graphics cards to motherboards. And for the vast majority of that hardware, it needs to be put through its paces on a quantifiable, standardized test bench. In short, we keep the system we use for each product we review identical, in order to ensure that our results across multiple motherboards, GPUs, CPUs, or memory kits aren't affected by any spurious system irregularities or instabilities.

Getting these things set in stone is imperative for providing solid, reliable results, and something many a hardware reviewer will pride themselves upon, ourselves included. But when it comes to building a solid test bench, there's a whole variety of factors to consider. First of which is the choice of chassis. Generally speaking, you have two routes: You can go with a fully enclosed case, or you can opt for an open-air test bench. The latter, however, tends to be less conducive to accurate cooling benchmarks (after all, it doesn't replicate a typical, everyday fully enclosed system). But case choice, accessible airflow, and ambient temperatures vary so widely among our audience, that it's often less about what specific temperature the coolers and fans can maintain, but more what variances in temperature and noise are noted between two different cooler designs, something we then balance with strict ambient temperature controls and thermal load testing. On top of that, opting for an open-air test bench makes swapping out hardware far easier and quicker. Which means that when it comes to supertests and error testing, it can be achieved far faster than when we're using a closed chassis.

As you've probably guessed, we're about to show you our test bench for 2017—which hardware we've chosen, which niggles we've found, and how we've overcome them.

HARDWARE VARIATIONS

SO, WHERE DID WE START with our new test bench? With the fixed components. We knew we wanted a new test bed, and Raijintek's Paean Aluminum ATX Bench Table caught our eye. Squeaky clean and providing far better mounting options than our previous one, it was the obvious choice. Next up was the cooler. We stuck with our trusty NZXT Kraken X61, coupled with two Noctua NF-A14 iPPC fans. It's not the fanciest AIO, but its vast surface area and fantastically easy mounting system make it a snap to set up.

We also decided to play around with our storage solutions this year. Moving the OS from the 500GB 850 Evo to the 250GB 960 Evo M.2, and using the Crucial MX300 1TB as our games and file storage drive, as opposed to the 2TB Samsung 850 Pro, made sense. Finally, Be Quiet!'s Dark Power Pro 11 1,200W PSU would be providing the juice, as it has done for the last 18 months.

This is where things get interesting—as we test a variety of products, the test bench has to rotate to compensate. A new X99 board? Then it's four sticks of DDR4 Dominators, alongside an Intel Core i7-6950X. AM4+ and Ryzen? A new motherboard and high-end processor should do the trick. GPUs launched? We'll stick with the Z270 setup, and swap the GTX 1080 out instead.

A test bench constantly changes, so while it has to adhere to strict principles on what hardware is included, it must be flexible enough to change depending on the gear being tested.

INGREDIENTS

PART		STREET PRICE
Case	Raijintek Paean Aluminum Test Bench	**$186**
Motherboard	Asus Maximus IX Hero	**$280**
CPU	Intel Core i7-7700K	**$340**
Memory	16GB (2x 8GB) Corsair Dominator Platinum DDR4 2,400MT/s	**$130**
GPU	Nvidia GeForce GTX 1080 Founder's Edition	**$700**
PSU	Be Quiet! Dark Power Pro 11 1,200W	**$240**
Storage 1	250GB Samsung 960 Evo M.2	**$130**
Storage 2	500GB Samsung 850 Evo 2.5-inch SSD	**$90**
Storage 3	1TB Crucial MX300 2.5-inch SSD	**$300**
Cooling	NZXT Kraken X61 + 2x Noctua NF-A14 iPPC	**$180**
Total		**$2,576**

1

FRONT I/O PROBLEMS

TEST BEDS TAKE THE MOST ABUSE of any system we put together here in the *Maximum PC* office. They have all sorts of hardware installed and pulled out again several times in one day, often three or four times a week. And because of that, they have to be built from the right stuff. Unfortunately, just one week in, we accidentally broke the front I/O on Raijintek's Paean, which meant we had to repair it using good old packing tape, just to keep it in one piece. It doesn't look particularly glamorous, but most test benches we've used prior to this lacked a front I/O altogether, with us either booting via an onboard switch or shorting the two power pins on the motherboard itself most of the time.

2

GHETTO RADIATOR MOUNTING

NEXT UP WERE COOLING ISSUES. By design, the Paean is meant to be a fully liquid-cooled test bench solution. The theory is, you place a combi res in here, with a pump to the right of the motherboard, then a triple thick radiator to the right of that. Although that's certainly a possibility, we're not keen on deviating from the more common AIO yet, because it's more relevant to consumers, at least in our eyes. That said, mounting it the traditional way means our tubes aren't long enough—so, to circumvent this, we attached the radiator sideways on the radiator panel, by carefully threading cable ties through the corners of each fan, using the radiator screw as our anchor point. This keeps it secure, and means we can still reach the processor with ease.

3

THE NEW STANDARD

WE'VE BEEN A BIG ADVOCATE of M.2 PCIe drives for quite some time now. In fact, if you're building a modern system, using any of the new chipsets from either Intel or AMD, your best bet is to go for an M.2 PCIe SSD for your OS. The sequential read and write speeds alone are mind-bending. It was a tricky decision to make, though, because they're still not widespread just yet, and on top of that, booting from them requires Windows 10, and you also need that chipset support or an add-on card to make it a reality. However, the 960 Evo won us over, purely due to its exceptional value for money performance-wise .

4

MULTI GPUs

ONE OF THE NEAT FEATURES of the Paean is the PCIe bracket. Now, we know what you're thinking—why on earth is this such a big feature? The thing is, the vast majority of test bench manufacturers seem to fail every single time they attempt this, with many using either pins or disproportionate supports for the GPUs, leading to frantic and troublesome mounting solutions. Fortunately, with its tempered glass, the Paean is just as much a showcase as a test bench, so the mounting solution here is exceptionally solid, and enables us to test up to four-way CrossFire or two-way SLI if we so desire.

5

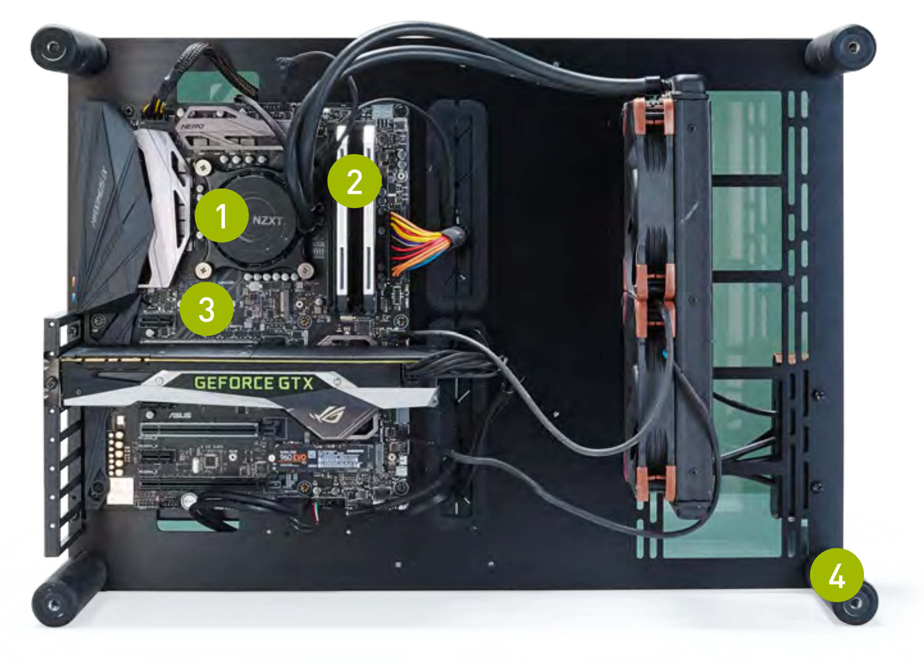
STORAGE CHANGES

NOT ONLY DID WE DECIDE to swap out the operating system to an M.2 PCIe SSD, but we also transferred all of our benchmarking files across from the Samsung 850 Pro 2TB on to this Crucial MX300. Now, let's be honest, it's not going to blow anyone away when it comes to performance, but as a workhorse drive for mass storage, it's exactly what we need. The Sammy 850 was being underused acting just as our games and files storage drive, and it has been put to better purpose elsewhere because of this change. On top of that, this neat mounting mechanism means we can pull the Crucial MX300 out whenever we need it, to hook it up to any system we choose with a USB 3.0 to SATA cable with relative ease.

6

CABLE MANAGEMENT? WHAT'S THAT?

OK, SO THIS ISN'T the tidiest build we've ever done (actually, we've always been pretty lax when it comes to cable management), but this is entirely for good reason. Because we swap out hardware at an alarming rate, we need slack cables to cater for the constant shuffling around. The last thing we want is to struggle to unplug a CPU or PCI power on the fly. You'll also notice we're still running our trusty 1,200W Be Quiet! Dark Power Pro 11 PSU. It's super, er, quiet, and has enough headroom to plug in multiple GPUs without much issue, making it one sweet piece of kit. We've also thrown in a few CableMod sleeved cables for good measure—although, due to the fact that this $240 PSU is semi-modular, we refused to plug in the extension lead for the 24-pin ATX.



1 Our NZXT Kraken X61 is looking a little withered at the moment, but we'll probably swap it out for a custom closed loop, featuring a triple 120mm radiator, later in the year.

2 Corsair's Dominator Platinums replace our trusty Crucial Ballistix Elites this time around, primarily because they're part of an 8x 8GB kit that we can use in our X99 platforms, too.

3 We had to make a special request to get the Maximus IX Hero in from Asus to be our dedicated test bench for 2017. It's a true performer, and looks pretty classy to boot.

4 We'll probably run this test bench with the glass side panel off. It makes it easier to access the insides, and the risk of getting fingers caught in fans is the least of our concerns.

OLD VERSUS NEW

OUT WITH THE OLD and in with the new, eh? It was a sad occasion when we benchmarked our Z170 test bed for the last time. It's performed admirably this year, and to be fair, a large chunk of it is staying with us. You may have noticed the Samsung 850 Evo 500GB is still plugged in the back, for instance, sitting next to the Crucial MX300—but, alas, it won't be making the journey with us, as it's purely there to transfer over any files we may need from the desktop, and is soon to be removed.

So, how was it to piece together? Well, open-air test benches are some of the easiest builds we ever create. The biggest challenge was assembling the Paean itself. The case comes flatpacked, so you have to attach the eight legs, then add all the other major components. The instructions could use some work, as we struggled to find the right screws for mounting the front I/O panel (probably what caused us to break it), and installing the PSU was a pain as well.

The biggest decisions were with regard to finalizing test benches for this year. We've all but wrapped up our Broadwell-E processor testing, so there's no need to pick a single X99 motherboard. As such, that test rig will remain pretty much cemented in place, with motherboards swapping in and out until we start seeing Skylake-X and its Kaby-X twin. For X99 motherboards, we'll use the Intel Core i7-6950X, with 32GB (4x 8GB) of Dominator Platinums. SSD testing will be handled by the new Kaby Lake base test bed, aka the Z270, with the same going for any new GPUs and coolers that come out, until a new consumer chipset arrives as well. And, of course, Z270 motherboard testing will be handled by the Core i7-7700K, the GTX 1080, and the storage solution we have on board. The real wild card is Ryzen. We're not sure what's going to happen with AMD's new champion and its chipset. However, it's unlikely we'll swap out from Z270, at least not until 2018. Same goes for GPUs, with AMD's Vega looking likely to launch in June of this year.

The big question is, do we get some proper water cooling on the go? We've certainly got the hardware to do it, but there are pros and cons. The positives? It would allow us to potentially push overclocks higher, as we wouldn't be so limited by thermal issues. And we can ensure the tubing is the correct length and the entire cooling table is controlled by us directly. Plus, it looks awesome. The negatives? Well, there's the fact that if we're reporting temperatures on CPUs (which we do, occasionally, for a new processor launch), it would mean swapping out the loop for an AIO, because the number of people using fully water-cooled loops like that would be very few. And, once Ryzen does launch, the AMD prodigies won't be using the same socket design as Intel, so we'd need to drain the loop and attach a new waterblock. Decisions, decisions.... ⏻

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread	923	963 (4%)
Cinebench R15 Single-Thread	179	193 (8%)
TechARP's X264 HD 5.0.1 (fps)	20.44	21.48 (5%)
CrystalDisk QD32 Sequential Read (MB/s)	549	3147 (473%)
CrystalDisk QD32 Sequential Write (MB/s)	522	1572 (201%)
Rise of the Tomb Raider (fps)	67	67 (0%)
Far Cry Primal (fps)	105	105 (0%)
The Division (fps)	101	102 (1%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point PC (the old test bench) uses a Core i7-6700K, 16GB of Crucial Ballistix Elite DDR4 at 2666, an Nvidia GTX 1080, and a 500GB Samsung 850 Evo. All games tested at 1080p on max settings, with HD texture packages installed.

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REVIEWS

TESTED. REVIEWED. VERDICTIZED.

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Intel Core i5-7600K

Third time lucky with 14nm

PULL UP A SEAT, and get comfortable. The following is gonna get philosophical, maybe even a little epistemological. The new Intel Core i5-7600K is very cool, you see. But it's also kinda crappy.

Hold that thought while we square away the speeds and feeds. The 7600K is, of course, part of Intel's new Kaby Lake family. That makes it a Tock in Intel's now-defunct "Tick Tock" cadence of processor development, where a Tock represents an architectural revision, rather than a new production process. Actually, it's the second such Tock on Intel's prevailing 14nm process, which reflects the fact that Tick Tock is dead, and now we have "Process, Architecture, Optimization." In simple terms, Intel can't keep up with its self-imposed strategy of introducing a new production process and then chip architecture in successive years. So Kaby Lake, with hindsight, has been classified as an optimization, the third 14nm family of CPUs following Broadwell and Skylake.

The 7600K slots into what has traditionally been the gaming enthusiast's favored slot, namely the top of the Core i5 model tree, complete with unlocked CPU multiplier for simple overclocking. As a Core i5 chip, it doesn't offer Hyper-Threading. Four cores and four threads are your lot. But with a base clock of 3.8GHz and a Turbo speed of 4.2GHz, it's 300MHz faster than its progenitor from the Skylake generation, the Core i5-6600K. 6MB of cache and support for dual-channel DDR4 memory up to 2,400MHz round out the key CPU specifications.

The chip also has Intel's latest integrated graphics in HD 630 trim. That's unlikely to be of much interest to most customers, almost all of whom will be pairing the 7600K with some kind of dedicated graphics solution. The possible exception to that involves support for 4K Netflix streaming, though that itself may be problematic in concert with a discrete graphics card, and immediately we are going round in circles. A complication for another day, we think.

AGAINST THE CLOCK

Anyway, to the benchmarks. At stock clocks, the new 7600K is unexciting. It's quicker than the old 6600K by about the amount you'd expect, based on the increased clock speeds. So that's single-digit increases in performance across the board, in percentage terms. That's definitely better than nothing. But it's also the sort of incremental improvement that's become the norm from Intel of late. The harsh truth is that you will struggle to feel the difference in the real world between the old 6600K and the new 7600K.

Until, that is, you throw overclocking into the equation. This thing really flies when you open up the overclocking taps. The old 6600K could typically crank up an extra 600MHz or so, or 4.5GHz overall. But the 7600K winds up to 5.2GHz with ease using auto voltage settings. That's a nice, round 1GHz overclock. It's been a long time coming, but with Kaby Lake, Intel CPUs are once again absolutely worth overclocking.

That's a very welcome and exciting development. But here's where the philosophizing comes in. Even with that overclock, you're only looking at about a 10 percent improvement in performance over Skylake. That's not a huge surprise, of course. Kaby Lake is a minor revision, not a brand new architecture. It doesn't have any additional CPU cores, either. Thus it's a far cry from the kind of step forward we once saw when Intel, say, first introduced a dual- or quad-core processor, and virtually doubled performance in one fell swoop.

Meanwhile, AMD's Ryzen is just around the corner, and if it's as good as we hope, we might finally see Intel pull out the stops and start adding cores to its mainstream CPUs in order to keep things competitive. All of which means the extent to which Kaby Lake and the new 7600K get you fired up is all about context. Compared to other recent refreshes, it's great. It's also indisputably the weapon of choice for gamers on a middling budget. But in the broader context of CPU development over the past decade, the 7600K is hardly revolutionary. It's not exactly cheap, either. –**JEREMY LAIRD**

VERDICT

8

Intel Core i5-7600K

+ FLYER Kaby Lake offers some serious overclocking chops; the new chip of choice for gamers.

− CRIER Still not a massive step forward in terms of performance; expensive for a chip with just four threads.

$250, www.intel.com

BENCHMARKS

	ZERO-POINT	
X265 Benchmark (fps)	14.37	15.86 (10%)
Cinebench R15 Single Core (Index)	166	179 (8%)
Cinebench R15 Multi Core (Index)	598	663 (11%)
FryRender Benchmark (m:s)	6:16	5:46 (8%)
AIDA64 Memory Latency (ns)	59.0	58.1 (2%)
Power Draw Idle (W)	49	45 (8%)
Power Draw Load (W)	114	112 (2%)
Total War: Attila @ 1440p (fps)	40	40 (0%)
Far Cry Primal @ 1440p (fps)	76	77 (1%)
3DMark Fire Strike (Index)	14,981	15,762 (5%)
Maximum OC (GHz)	4.9	5.2 (6%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our test bed consists of an Asus Maximus IX Hero, 16GB (2x 8GB) of Corsair Dominator Platinum @ 2,400MT/s, a Samsung 960 Evo 250GB M.2 SSD, and a 1TB Crucial MX300 SSD. Zero-point is a Core i5 6600K.

SPECIFICATIONS

Base Clock	3.8GHz
Turbo Clock	4.2GHz
Cores	4
Threads	4
Lithography	14nm
Cache	6MB
Memory Support	DDR4 up to 2,400MHz
Memory Channels	Dual
Max PCIe Lanes	16x PCIe 3.0
Graphics	Intel HD 630
TDP	91W

INTEL® CORE™ i5
i5-7600K
SR32V 3.80GHZ
L639F866 e4

The Core i5-7600K is a familiar package, but with an overclocking twist.

Eurocom Sky X9E2

A portable gaming monster

WE ONCE HEARD the original Xbox described as "Batman's briefcase crossed with a supercomputer." Apologies to Microsoft, but Eurocom's Sky X9E2 now deserves that mantle. This beast of a gaming machine is one of the most powerful portable systems we've ever tested. Of course, "portable" is something of a relative term. The Sky X9 itself weighs in at (only) 12 pounds—not bad, considering the hardware inside—but it requires two massive 330W power bricks to run at full juice, and those weigh nearly three pounds each.

Of course, all that weight is well spent. Packed inside the Sky X9's minimalist black case is more power than most high-end gaming desktops. An Intel Core i7-6700K clocked at 4GHz serves as the brains of the operation, with a turbo up to 4.2GHz supported. We actually managed to overclock the CPU even higher, but more on that later. For storage, our unit was equipped with a single 512GB Samsung SM951 NVMe SSD, but the system can support an additional M.2 SSD, as well as up to two 2.5-inch drives. RAM amounted to 32GB of DDR4-3000, while ports included five USB 3.0 (one of them powered), two Thunderbolt 3, two mini DisplayPort 1.3, and one HDMI 2.0 output. The full-size keyboard features full RGB backlighting, and the touchpad is equipped with a biometric fingerprint reader. But the crowning component is the twin desktop-class GeForce GTX 1080 GPUs in SLI.

It should go without saying that the Sky X9 is more than capable of running any game at 1080p max settings. However, in our testing, we found that GTX 1080 SLI does not play nice with lower resolution formats. *Rise of the Tomb Raider* and *Far Cry Primal* both performed better in 1080p with SLI disabled, pulling in an average of 130fps and 104fps respectively, compared to 101fps and 80fps with SLI activated. *The Division*, on the other hand, benefitted from the extra GPU at 1080p ultra, performing at an average of 137fps, as opposed to 100 without SLI enabled. 3DMark Fire Strike also enjoyed the extra GPU juice, scoring 20,237 without SLI, and 22,473 with.

But why would you want to game at 1080p when you have two GTX 1080s and, more importantly, a G-Sync enabled 4K screen. (The system can also be configured with a 2560x1440p 120Hz TN screen, also with G-Sync.) We're usually hesitant to recommend gaming at 4K, as even the GTX 1080 struggles to consistently lock down 60fps without a twin to share the load. But that's exactly what the Sky X9 has inside, and it does the job swimmingly. Luckily, every game we tested benefitted from the second GPU. More impressively, the pair of cards was able to consistently stay above 60fps in 4K resolution, even with the settings cranked up to the max. We recorded an average of 78fps across *Rise of the Tomb Raider's* three-part benchmark at 4K max settings, while *Far Cry Primal* and *The Division* scored 73 and 66fps respectively. Needless to say, it's incredibly impressive to perform at such a high bar—to do it on a laptop is just insane.

SOME LIKE IT HOT

With all its stellar gaming performance, the most impressive thing about the Sky X9E2 is its portability. Sure, you'll never actually use it on your lap, but even with its massive twin power bricks in tow, the Sky X9 can be put in a backpack and lugged across town—or across the country. It would be heavy, yes, but not nearly the weight of carrying a full-size desktop rig. It also doesn't require an external cooling dock, like the Asus ROG GX800VH we reviewed way back in our Holiday issue. It's worth noting that, despite being listed as optional, we found the second power brick to be a requirement. The system boots up and charges with only one PSU attached, but as soon as the GPU heats up and the fans start spinning—even with SLI disabled—it draws too much power for the single brick to handle. After a few minutes playing *Overwatch* (in 1080p with SLI disabled), the brick shut itself down, switching the system over to battery, and massively throttling performance.

Speaking of heat, man does it get hot. Eurocom says the system's "state-of-the-art thermal solution" uses industrial-grade copper heatsinks, centripetal fans, and a layered, socketed motherboard system designed for thermal efficiency. What that means in practice is a trio of crazy-loud fans blasting heat out the back. They keep the components cool, as we didn't have any internal thermal issues, even when overclocking, but we'd be wary of situating anything heat-sensitive around back.

All the testing (and benchmarks opposite) were conducted without overclocking, but thanks to Sky X9's Z170 chipset, you can squeeze a bit of extra power out of the CPU and GPUs. The unlocked Core i7-6700K is clocked at 4GHz and listed as overclockable up to 4.2, but we managed to push it as high as 4.5GHz without major instability. The GPUs, similarly, can handle a bit of extra juice, though we only saw an improvement of 2–3fps in *Tomb Raider* at 4K. It didn't really seem worth the effort, but then, every frame matters when trying to eke out 60fps in 4K.

All told, the Eurocom Sky X9E2 is an incredibly impressive system. Could you get equal or better (and quieter) performance out of a desktop build? Sure, but you can't toss a desktop into a backpack, and take it through airport security. Of course, all that power comes with an equally impressive price tag. Our system, as configured, clocked in at $5,683. But at least your wallet will be lighter. **–BO MOORE**

VERDICT
9
KICK ASS!

Eurocom Sky X9E2

+ FIRST CLASS Portable 4K 60fps at max settings; understated design; surprisingly light.

− COACH Crazy loud; hot; needs two large power bricks; super expensive.

$5,683, www.eurocom.com

The Sky X9E2 delivers consistent 4K performance in a body that's actually portable.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 (Index)	682	847 (24.2%)
Tech ARP x264 (fps)	15.17	19.06 (25.6%)
CrystalDiskMark 4K Read (MB/s)	44	53 (20%)
CrystalDiskMark 4K Write (MB/s)	162	180 (11%)
Far Cry Primal (fps)	37	80 (116%)
The Division (fps)	33	137 (315%)
Rise of the Tomb Raider (fps)	42	101 (140%)
3DMark Fire Strike (Index)	6,583	22,473 (241%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus G752VT-DH72, with an Intel Core i7-6700HQ, a 3GB GTX 970M, and 16GB of DDR4-2133.

SPECIFICATIONS

Processor	Intel Core i7-6700K @ 4GHz
Graphics	2x Nvidia GeForce GTX 1080 SLI
RAM	32GB (4x 8GB) DDR4-3000
Screen	17.3-inch 4K G-Sync IPS
Primary Storage	Samsung SM951 512GB NVMe M.2 SSD
Keyboard	Backlit full-size keyboard with numeric pad
Cooling Solution	Copper heatsinks paired with centripetal fans
Battery	8-cell Smart Li-Ion 89W
PSU	2x 330W
Total Weight	12.1lb (17.8lb including 2x PSU)

The Spectre is delightfully thin, but it's not to everyone's tastes.

HP Spectre

Portability and power—fantasy or the new reality?

THE DREAM OF POWER and portability is often pondered on these pages. We see plenty of powerful desktop replacements, and a fair selection of svelte ultrabooks, too, but very few systems have managed to successfully combine both disciplines. The latest system attempting to tackle this tricky marriage is the HP Spectre—a super-thin machine that appears to pack a list of impressive hardware into its diminutive form.

First, a quick word on looks—this machine isn't going to excite everyone. The faux bronze rear bar and hinge are a touch too kitsch for some, and the large bezel around the screen annoyed a couple on our team as well. So, even if you like it, don't expect everyone to swoon in a similar way. The materials do feel a little plasticky compared to a certain fruit-themed competitor, too. Even so, the system's weight and size are well balanced—it's light, but not flimsy, and compact without being pokey.

The screen is a sensible compromise of current tech—the 13.3-inch Full HD display offers a reasonable 166 pixel per inch, and gives the integrated Intel HD Graphics 520 an (admittedly slim) chance of rendering games at the native resolution. We're sure there's a marketing bod somewhere who's apoplectic about it not being a 4K display, but at this screen size, such a move would do little more than give you a headache.

Working our way around the laptop, there's not much on offer in the form of connectivity. The sides are too thin to house USB slots, so the only ports you'll find are on the back edge of the machine. There you'll find three USB 3.0 Type-C ports (one of which doubles as the charging port) alongside a 3.5mm audio jack. The latter being useful should the built-in Bang & Olufsen speakers not quite fit the bill for your public audio entertainment—the sound quality is reasonable enough, mind.

USB Type-C connectors may be the future, but as any Apple fanboy will attest, you're going to need a USB converter until that future arrives. The good news is that most things are covered well by the Spectre itself. The keyboard is comfortable to type on, and there's subtle under-key lighting to help you navigate in the dark. The touchpad is a good size and silky smooth in use. However, we did find the left and right buttons took some getting used to, although because you can't easily plug in a mouse (due to the lack of Type-A ports), it's worth persevering with that touchpad.

COUNTING CORES

On the whole, the criticisms thus far have been minor: Our main reservation is with the processor. The Core i7-6500U may have you thinking this is a veritable cutting-edge powerhouse, but it's better thought of as a Core i3, as it only boasts a pair of physical cores. Yes, it does boost this with Hyper-Threading, so it can handle four threads at once, but with most Core i7s laying claim to four physical cores and eight threads, this CPU looks a little less impressive than the specs may suggest.

Our fears are born out in our benchmarks, with scores roughly half of what we'd expect at this price. At least the storage subsystem provides a fair lick of speed—and, to be fair, when it comes to normal use, it genuinely feels speedy. And given the form factor, it's arguably the portability that is more important. That said, we weren't overwhelmed by the machine's stamina either—managing just under four hours when playing Full HD video is hardly remarkable. We would have liked to see much more from this machine.

Overall, while the Spectre checks many of our boxes, particularly on the aesthetic and form factor front, it ultimately pulls up short in areas where it needs to excel. More raw power from the processor would be an obvious place to start, and a better battery wouldn't hurt either. An updated spin of this machine boasting a Kaby Lake CPU will be available soon, and that could help things significantly. As of right now, though, it's just shy of brilliant. **–ALAN DEXTER**

VERDICT 7

HP Spectre

＋ REFINED Sweet design; light; quality audio; vibrant screen; responsive storage.

－ DILUTED Weak CPU; poor graphics; only Type-C USB ports.

$1,395, www.hp.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 (Index)	682	306 (-55%)
X264 HD 5.0 (fps)	15.17	6.24 (-62%)
CrystalDiskMark 4K Read (MB/s)	44.2	43 (-3%)
CrystalDiskMark 4K Write (MB/s)	162.1	151 (-7%)
Battery Life (Mins)	153	226 (48%)
Rise of the Tomb Raider (fps)	42.3	2.6 (-94%)
3DMark Fire Strike (Index)	6,583	3,547 (-46%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus G752VT-DH72, with an Intel Core i7-6700HQ, GTX 970M, and 16GB of DDR4. *Rise of the Tomb Raider* tested at Very High settings with SMAA at 1080p.

SPECIFICATIONS

Processor	Intel Core i7-6500U
Graphics	Intel HD Graphics 520
RAM	8GB LPDDR3
Resolution	1920x1080
Display	13.3-inch, IPS
Storage	512GB NVMe SSD
Connectivity	3x USB 3 Type-C
Dimensions	12.8 x 9.03 x 0.4 inches
Weight	2lb 9oz
Warranty	One year

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MSI Z270 XPower Gaming Titanium

A Z270 return for silver surfer

SO MANY MOTHERBOARDS! This certainly isn't the first, nor shall it be the last Z270 mobo we review. MSI's XPower Gaming Titanium is the new Z270 motherboard from the Micro-Star labs, and boy is she pretty. Lacquered from head to toe in a combination of black and silver, this ATX mobo is as striking as it is powerful. Designed for overclockers seeking the maximum level of performance possible, the XPower supports a plethora of overclocking choices, including voltage measure points, an additional section of PCB with onboard buttons to increase and decrease voltage and multiplier, and, of course, full support for LN2 and disabling fast boot mode, to whip those high-end frequencies into shape.

But that's not what really interests us about this motherboard. No, it's something a little more down to earth: storage. If you've glanced over at the shot on the left, you may have spotted a curious little addition, resting snugly in the middle of the bank of PCIe slots. A small, thin, detailed strip of metallic alloy, adorned with the words "M.2 Shield." It addresses one of the biggest issues M.2 PCIe drives face: thermal throttling. Regardless of whether you have a $1,400 2TB Samsung 960 Pro, or a $120 256GB ADATA XPG SX8000, you're going to encounter thermal throttling issues. No matter how much it costs, at a certain point, every drive begins to throttle. Samsung claims that its new 960 Pro drives dissipate just enough heat—thanks to an intuitively designed "heat-spreader label" (yup, that's a thing)—that they don't begin to throttle until after 333GB of data has been transferred on to or across from the device. That's a hefty figure, but as you reduce price and investment, thermal throttling becomes more of an issue.

SHIELD EVERYTHING

This is where MSI comes in. The M.2 shield is comprised of two components: the metal top, and an additional thermal pad below the guard. This touches the very top of the memory chips on the M.2 drive, drawing heat up and away from it, and into what effectively becomes a heatsink. This means that more aggressive workloads can be handled for longer, without the drive throttling—plus, it hides those god-awful ugly green PCBs neatly away.

Keeping with storage, there's a few other tidbits we really appreciated here, too. The inclusion of three M.2 ports, RAID-enabled for astronomical sequential reads and writes, is a nice touch. And although we're still not certain whether it's a dud or not, Intel's U.2 connection standard (something that was limited to Asus motherboards, last gen) is also supported below the usual plethora of SATA ports.

On to performance, then. In short, we weren't super-impressed with how well the XPower Gaming Titanium performed this time around. As we write this, we're still strictly under NDA, with Intel not set to launch its new Kaby Lake desktop experience for at least another two weeks—however, first impressions aren't exactly overwhelming, especially for an overclocking board. In our tests, we achieved lower overclocks, with higher voltages, across our testing range. The XPower needed 1.3V on the Vcore to achieve 5GHz on our current Core i7-7700K, versus the Asus Maximus IX Hero's 1.27V. It achieved a maximum stable overclock of 5.0GHz, versus the Asus's 5.1GHz. And the lowest voltage we managed to keep the core running stable with at stock was a dismal 1.09V, versus the Hero's 1.07V. Now, you could say we're splitting hairs here, but the Hero is designed to be a mainstream board, while the XPower is aimed at the upper echelons of world record breakers. It's possible we may see some improvement in the future, thanks to BIOS updates and software reworkings, but, for the time being at least, the XPower doesn't quite hit the mark. **–ZAK STOREY**

VERDICT **8**

MSI Z270 XPower Gaming Titanium

➕ XTREME Great M.2 shield innovation; stunning looks; solid performance; nice overclocking features.

➖ XCEPT Just doesn't overclock as well; needs a BIOS update.

$320, www.msi.com

BENCHMARKS

	MSI Z270 XPower Gaming Titanium	Asus Maximus IX Hero
X265 Benchmark (fps)	**21.15**	21.02
Cinebench R15 (Index)	**984**	977
FryRender (m:s)	**3:36**	**3:36**
AIDA64 Memory Latency (ns)	59.7	**59.5**
CrystalDisk Sequential Read/Write (MB/s)	**3,249/1,589**	3,131/1,546
Power Draw Idle/Peak (W)	45/131	**43/126**
Far Cry Primal @ 4K (Average fps)	42	**43**
3DMark Fire Strike Extreme (Index)	**9,595**	9,442
Maximum Overclock Achieved (GHz)	5.0	**5.1**
Lowest Undervolt @ Stock (V)	1.09	**1.07**
Lowest Voltage @ 5GHz (V)	1.3	**1.28**

Best scores are in bold. Our test bench consists of an Intel Core i7-7700K (separate chip to Asus Maximus IX Hero review), 16GB Corsair Dominator Platinum @ 2,400, GeForce GTX 1080, and 250GB Samsung 960 Evo PCIe SSD.

SPECIFICATIONS

Chipset	Z270
Socket	LGA 1151
Form Factor	ATX
Memory Support	64GB DDR4 @ 4,133MT/s
M.2/U.2 Support	3x M.2 PCIe x4
SATA Support	8x SATA 6Gb/s
Max PCIe Support	4x PCIe 3.0 x16
Rear I/O	3x USB 2.0, 4x USB 3.0, 1x USB 3.1 Type A, 1x USB 3.1 Type C, 5.1-channel audio, optical out, Intel Gigabit Ethernet, Killer Gigabit Ethernet, HDMI 1.4(b), combi port, 1x DisplayPort 1.2.

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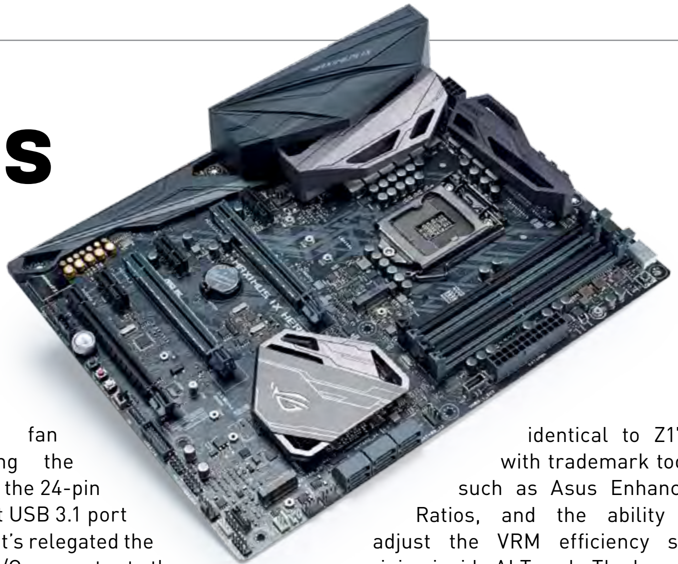
Asus Maximus IX Hero

Small changes, big difference



KABY LAKE has launched, and we're on our way to being buried by the latest and greatest from the big three motherboard manufacturers. Asus, MSI, and Gigabyte are churning out new iterations faster than we can say "Conway Twitty," and that's no bad thing. These boards have been in development for some time, and with the first murmurs heard back at CES 2016, it's easy to understand why manufacturers are so eager to get their foot in the door, and your money in their pockets.

Here we have the kingpin of Asus's motherboard arsenal, and a follow-up to one of its best-selling mobos of all time. The Maximus IX Hero is a beauty. Asus has done away with the black and red of its eighth-generation ROG predecessor, opting for a dark black and metallic aesthetic instead. The reason is obvious, and something Asus corrected with the launch of the Maximus VIII Formula: If you have a red motherboard, it's not going to work well with any color other than red, white, or black. This new aesthetic, combined with the lighting on both the chipset and the rear I/O plate, ensures that you can color-coordinate your system without worry.

Moving on, Asus has included an additional M.2 port below the processor, two more fan headers along the side closest to the 24-pin power, a direct USB 3.1 port on board, and it's relegated the USB 3.0 front I/O connector to the bottom of the board, as opposed to its usual position cozying up to the 24-pin. On top of that, Asus has stripped the Maximus IX Hero of SATA Express ports entirely, and as a result, it's also lost two of the SATA 3 ports. Considering the damp squib that SATA Express became, we're not sad to see it go. An interesting change we didn't expect to witness is the lack of U.2 port, especially as Asus reintroduced the Hero Alpha featuring the U.2 port as standard. Diving into the box, there isn't even an M.2 to U.2 adapter. This suggests that Asus isn't putting as much faith in U.2 as it is M.2, which makes sense, especially when you consider just how tightly locked Intel has the U.2 connection standard. And, to be frank, with the likes of Samsung producing some fantastic M.2 drives, with higher capacities and better performance than many of Intel's best U.2 SSDs, we're not particularly surprised.

BIOS-wise, the Hero IX is the same familiar affair we're all used to. Overclocking features remain resolutely identical to Z170, with trademark tools such as Asus Enhanced Ratios, and the ability to adjust the VRM efficiency still remaining inside AI Tweak. The board's overclocking performance is strong as well, with our chip achieving an impressive 5GHz, with a meager 1.25V on the VCore. VDroop is less than 0.01V, and overall performance is exceedingly similar to our other Asus board.

All in all, this update to the Hero board changes a good deal of aesthetic properties, while removing a lot of the wasted space allocated to older connection standards that just weren't cutting it anymore. We do wish Asus had included one additional USB 3.0 internal header, but otherwise there's very little for us to complain about. If you're thinking of upgrading from Ivy Bridge or Haswell, the Maximus IX Hero, in combination with a Core i5-7600K or above, is a fantastic solution. –ZAK STOREY

VERDICT

9

Asus Maximus IX Hero

+ **MAN OF STEEL** Perfect aesthetic; refined RGB lighting; unused connection standards removed; improved cooling support; overclocking.

− **BIRD MAN** Heatsink could be fancier; high power draw under load.

$300, www.asus.com

BENCHMARKS

	Asus Maximus IX Hero	Asus TUF Z270 Mark 1
X265 Benchmark (fps)	**21.06**	20.68
Cinebench R15 (Index)	**981**	970
FryRender (m:s)	**3:37**	3:45
AIDA64 Memory Latency (ns)	59.5	**55.2**
CrystalDisk Sequential Read/Write (MB/s)	**551/530**	549/527
Power Draw Idle/Peak (W)	**43**/126	44/**110**
Far Cry Primal @ 4K (avg fps)	**43**	42
3DMark Fire Strike Extreme (Index)	9,462	**9,522**
Maximum Overclock Achieved	**5.2GHz**	**5.2GHz**
Lowest Undervolt @ Stock (V)	**1.15**	**1.15**
Lowest Voltage @ 5GHz (V)	**1.25**	**1.25**

Best scores are in bold. All benchmarks performed with an Intel Core i7-7700K, 16GB of DDR4 2400 (2x 8GB), GeForce GTX 1080, and a Samsung 850 Evo 500GB.

SPECIFICATIONS

Chipset/Socket	Z270/LGA 1151
Form Factor	ATX
Memory Support	64GB DDR4 @ 4,133MT/s
M.2/U.2 Support	2x M.2 PCIe x4
SATA Support	6x SATA 6Gb/s
Max PCIe Support	3x PCIe 3.0 x16
Rear I/O	4x USB 2.0, 4x USB 3.0, 1x USB 3.1 Type A, 1x USB 3.1 Type C, 5.1 channel audio, optical out, Intel Gigabit Ethernet, HDMI 1.4(b), 1x DisplayPort 1.2

Samsung 960 Evo 250GB

Proof that cache comes at a cost

SAMSUNG'S PREMIUM "PRO" DRIVES are pretty much the go-to SSDs for enthusiasts seeking the best in solid-state storage performance. The latest 960 Pro is a barnstormer of an SSD. But it ain't cheap.

In 512GB M.2 configuration, the smallest option, it rocks in at a recommended retail of $329. That's pretty fancy for the 500GB segment, which is where the 960 Evo steps in, again in M.2 format. Like previous "Evo" models, it gives you much of that Samsung SSD goodness, just in a more affordable package. That's the theory, at least.

The core specs certainly look promising. For starters, you can have it in 250GB format, as tested here, which brings the price down dramatically. It's well under half the price of the smallest 960 Pro. But like the Pro, the Evo also comes with the Polaris controller chip. That's Samsung's latest controller. With the Polaris chip comes support for both quad-lane PCI Express 4.0 connectivity and the solid-state-friendly NVMe control protocol.

Where things begin to differ involves the flash memory. Both drives sport Samsung's cutting-edge V-NAND, so-called because of the layers (48 of them) of memory cells, stacked vertically atop one another. The difference with the Evo compared to the Pro is that it gets triple-level cell memory to the Pro's dual-level. The former makes for greater data density and thus lower prices. But it also comes at a cost to both performance and durability.

In terms of the official specs, the impact varies. The peak sequential numbers look solid at first glance, even for this entry-level 250GB drive. Samsung says it's good for 3.2GB/s reads and 1.5GB/s writes. The latter is a fair distance off the 2.1GB/s of the smallest 960 Pro, for instance, but it's still a big old number.

CACHE FLOW

Look closely at the spec sheet, however, and you'll note that write performance is enabled by the SLC write cache, a block of flash memory running in single-level mode and acting as a write buffer. For this 250GB drive, it measures 13GB. Problem is, if you exhaust the cache, performance drops off dramatically. Samsung says sustained performance once the cache is filled comes in at just 300MB/s. Yikes.

Drive endurance, meanwhile, tumbles from 400TB for the entry-level 960 Pro to 100TB. Similarly, Samsung clips the Evo's warranty down to three years from the Pro's five years. That said, there's less collateral damage to the cost-cutting when it comes to random access performance. The Evo 250GB is good for 330K IOPS reads and 300K writes.

The Evo delivers on its claimed peak performance in a benchmark like ATTO, with 3.2GB/s reads and 1.5GB/s writes. More nuanced metrics that sidestep tricks such as on-the-fly compression, however, show the limitations of the Evo's cost-conscious configuration. For starters, it only musters around 1.7GB/s reads in CrystalMark's sequential benchmark.

The more revealing measure is the 89 seconds the Evo needs to motor through our 30GB internal file copy test—roughly twice as long as the Pro needs. On the other hand, the Evo is seriously slick in CrystalMark's 4K random access tests. 4K performance makes a big difference to how responsive a drive feels, so it's great to see that the Evo scores well there.

How much you're worried by the patchy sequential performance depends on your workloads. The Evo is still fast, especially compared to anything that hooks up to an old-school SATA interface. But if you routinely shunt large files around, you will inevitably keep bumping into the limitations of that SLC cache. Those caveats aside, this is a nice little M.2 drive from arguably the best in the SSD business. **–JEREMY LAIRD**

VERDICT
8

Samsung 960 Evo 250GB

+ SPEEDY Quad-lane PCIe connectivity and NVMe is quite a combo; Samsung's latest controller chip.

– NEEDY LC cache tech has limitations; sequential throughput isn't sustained.

$129, www.samsung.com

BENCHMARKS

	Samsung 960 Evo 250GB	Samsung 960 Pro 2TB	Intel 750 PCIe 1.2TB
CrystalMark Sequential Read (MB/s)	1,682	**2,636**	1,298
CrystalMark Sequential Write (MB/s)	1,475	**2,077**	1,271
CrystalMark 4K Random Read (MB/s)	**64**	57	37
CrystalMark 4K Random Write (MB/s)	191	194	**326**
ATTO Sequential Read (MB/s)	3,019	**3,410**	2,600
ATTO Sequential Write (MB/s)	1,494	**2,100**	1,400
5GB Zip Compression (Mins:Secs)	**3:14**	3:16	3:16
30GB Internal File Copy (Mins:Secs)	1:29	**0:41**	0:42

Best scores are in bold. Our test bed consists of an Intel Core i7-6700K, an MSI Z170 Gaming M7 motherboard, a Samsung 850 Evo 500GB, and a Be Quiet! Dark Power Pro 11 power supply.

SPECIFICATIONS

Capacity	250GB
Interface	PCIe 3.0 x4
Control Protocol	NVMe
Controller	Samsung Polaris
NAND Type	48-layer V-NAND
Sequential Read/Write	3.2/1.5GB/s
Read/Write IOPS	330/300K
Warranty	Three years

SteelSeries Arctis 3

Cool, but by no means calm, audio

STEELSERIES HAS LADLED on the gimmicks with its sport-inspired Arctis series, and while the model 3 lacks the USB connectivity and RGB lighting of the Arctis 5 ($20 more), and the wireless convenience of the Arctis 7 ($70 more), it's still toting the lion's share of the family's genius touches. So, let's dissect, starting with that funky ski-goggle headband, a feature most commonly seen on concept VR headsets. It makes the Arctis 3 infinitely adjustable and, once you've got it set just right, monumentally comfortable. It does take a little getting used to, since—despite claims that it eliminates pressure points—it seems to exert more direct pressure across your dome than a traditional padded band would. We'd like to blame at least one early headache on wearing it before it was properly adjusted, although our legal advisors point out that it could equally have been caused by our simultaneous, unblinking analysis of 4K footage.

Next up on the block, the Arctis's modular cabling. It's wonderfully long and stylishly gray. It gives you the option of switching between a four-pole and a pair of three-pole jacks in a tidy way. It is also a colossal pain in the rear. Several times during our test, we had the heart-in-mouth worry of audio dropping out. Would we have to send a trashed headset back to SteelSeries with a groveling apology? No. We'd have to plug the cable back in to the right earpiece, or into the mid-cable join, where it had worked its way loose because we'd deigned to move our head just slightly. A little thing—probably not a deal-breaker, considering you're unlikely to end up in a situation where a frayed cable renders your $80 headset useless—but it's irritating nonetheless.

The slide-out bendy mic is super-neat, and among the best microphones we've tested on headsets in this price range. It's clear, sensitive, and stands up very well to being boosted by software. If you're buying this for speaking, you won't be disappointed. Again, though, the specter of irritation creeps in. It's bendy, but doesn't seem to want to stay exactly where you've put it, and it's an absolute magnet for disgusting breathing noise. What's more, the mic mute function is reached through a tiny, lightly recessed button on the right ear; finding it while wearing the headset is hard enough, let alone finding it without inadvertently knocking the cable out....

SKULLDUGGERY

Despite a couple of questionable design choices, the Arctis 3 is a well-constructed, sexy-looking set of closed-back cans, with 90-degree earpiece rotation, and pillow-soft velour pads—dubbed "Airweave" by SteelSeries—that feel just awesome. It's light enough, and we found it a lot less tight on the head than other headsets, perhaps because of the unusually narrow head of your reviewer, or perhaps because it really is a little looser. Whether this is a positive or negative feature depends on both your skull and your personal preferences.

We've hit a lot of negative niggles, so here's the turnaround: the Arctis 3's audio quality is fantastic. Seriously, it's delicious. There's a brilliant, well-balanced sound stage on offer, one that doesn't fight you with overwhelming bass, or pierce your ears with spiky treble. The middle doesn't get lost, and the details remain pin-sharp. But don't make the mistake of thinking it's at all flat—this headset is the elected mayor of Rich City, and it's not going to be leaving office for some time. We could, and did, sit and listen to the Arctis's S1 drivers all day, although the 7.1 surround didn't blow us away like we thought it might. Does it stand up to the same-price HyperX Cloud II in terms of overall construction quality and design acumen? No. But it could be more comfortable if your head suits it, and it's a definite contender in the audio stakes—niggles and all. **–ALEX COX**

VERDICT 8

SteelSeries Arctis 3

⊞ **AIRWEAVE** Comfortable (eventually); great mic quality; fantastic audio.

⊟ **AIRLEAVE** Awkward cabling; wayward design; loose fit.

$80, www.steelseries.com

SPECIFICATIONS

Driver Type	40mm neodymium
Impedance	32 ohm
Frequency Response	20Hz–22KHz
Design Style	Closed-back
Microphone Type	Bidirectional, noise canceling
Connectivity	3.5mm jack
Weight	9.6oz
Cord Length	10 feet

Razer DeathAdder Elite

When he had pressed the seventh button, there was silence in heaven

NOT A SELF-AWARE calculator from Cyberdyne Systems, but the latest in a familiar line from Razer. The Elite marks the DeathAdder's tenth anniversary in style, by adding a couple of extra buttons, for a total of seven.

That's a little unfair. There's a new optical sensor, too, squeezing an extra 6,000 dots into every inch when compared to the DeathAdder Chroma, and new Razer-made switches under the buttons, now rated for 50 million clicks.

The DeathAdder has always been Razer's Jack-of-all-trades gaming mouse, aimed at those who don't like to specialize in one kind of title, but let their fingers wander all over the Steam store. Despite this, Razer has chosen to plaster the promotional material with its eSports branding. For once, however, it makes a bit of sense—the DeathAdder Elite is built around accuracy and speed, two things that might have an effect when a few pixels make a difference between who wins and who's left crying into their Gatorade.

Anybody who's not competing for large prize pots will be happy with the mouse, too, unless you try to hold it in your left hand. There's not even a hint of ambidexterity about the DeathAdder, and Razer produces a left-handed version of the DeathAdder to compensate for those who, according to a study from the University of Montpellier, are better in fights. The strictly right-handed ergonomics means that it's a good fit for a lot of hands, with the rubber pad below the side buttons providing a particularly grippy surface from which to flick your thumb up to the switches above.

There's another grippy patch on the other side, perfect for the third finger while your first two are on the main buttons, which are molded into the top of the mouse, and have a cute little cleft in them, so your fingers can slip perfectly into the sweet spot. The back of the mouse is humped, ready to support your palm as you bash away at your games, leading to less fatigue if you're in the habit of spending hours twitching back and forth before achieving a satisfying conclusion. The two new buttons nestle just above the wheel, which has newly sprouted nodules on it, in a departure from the chunky divisions of the DeathAdder Chroma. We don't know whether it makes it any easier to rotate, as the Chroma's wheel was already pretty good at that, but you certainly know when your finger is gently caressing it, with no chance of mistaking it for the body of the mouse and making a horrible mistake.

CLICKY QUESTIONS

Unlike every other gaming mouse manufacturer in the world, Razer doesn't use Omron switches. Instead, it creates its own.... in association with Omron. This puts us in a philosophical situation—are the switches Omrons or not? And does it matter? The answer is "not really"—Razer's switches are responsive, give a decent click (every bank of buttons makes a different noise, the wheel and two new buttons rather muted compared to the bright, trebly clicks of the main buttons, with the side switches somewhere in between), and with the huge lifespan now built into them, could be bothering your online opponents for many years to come.

Underneath, two shiny plastic panels keep the mouse sliding slickly over the desktop, while the sensor sits behind a very understated rectangular window. As this isn't the kind of customizable mouse that keeps weights handy, there's no removable panel to go poking around behind. Customization comes from the 16.8 million color Chroma lighting system and the programmable buttons, all controlled through the usual Synapse software.

This is a reasonably priced mouse in a world where you can spend a great deal more money and not get such a well-made product. What it lacks in bells and whistles, it makes up for in subtlety and class, and by concentrating on accuracy and speed, it zeroes in on the things mice are meant to do. –**IAN EVENDEN**

VERDICT **9**

Razer DeathAdder Elite

+ ELITE Well made; fast and accurate; fits nicely to the hand.

− DELETE Right-handers only; too many buttons for some, too few for others.

$70, www.razerzone.com

SPECIFICATIONS

Sensor Type	Optical
Sensitivity	16,000 dpi
Sensor Model	Razer 5G Optical
Polling Rate	1,000Hz
Programmable Buttons	7
LEDs	2-zone, 16.8 million colors
Cable Length	7 feet
Weight	3.7oz

BitFenix Pandora ATX

Budget cooling craftsmanship

BITFENIX HAS LONG been a favorite for those looking for a mid-range chassis. The Shinobi, for instance, was exceedingly popular because of its simple design and affordable price point. Over the years, the company has continued to innovate, turning away from the traditional rectangular box in search of ever more outrageous angles and designs. First came the Prodigy, followed by the Pandora, then the Aurora, all featuring the curvaceous style that BitFenix is now known for. Speaking of the Pandora, it's one of the few cases we've never reviewed—until now. However, instead of requesting the little-bitty microATX variant, we decided to opt for the more rambunctious full-tower version.

From the get-go, it certainly hits the mark for that bonkers style we associate with BitFenix. The curved steel side panels meld into the front of the chassis, held on by two screws at the rear and a simple pop-hinge near the front. They're not the sturdiest of panels, and there's a degree of flex to the two of them, but they get the job done, and should easily help mask cable management issues without worry.

The real showpiece, however, is the LED logo at the front of the case. Connecting to the motherboard via a single internal USB header, you can change and adjust the logo that's shown on the 2.8-inch color display through software. It's worth noting that this option isn't available on the more budget-friendly Core variant, though.

The internal layout looks good, too. There are mounting trays for two 2.5-inch SSDs to be displayed through the window, a 3.5-inch mount just above the PSU cover, and a rubberized pump mount, too, along with the usual plethora of rubber grommets. Looking behind the motherboard tray, you'll find two additional 2.5-inch mounts, and a second 3.5-inch hidden below the PSU cover, as well.

But it's the cooling support where you'll find the really neat features. There's a recessed radiator port—which supports up to a 360mm radiator in the roof—just above the motherboard tray, carefully tucked away out of sight, followed by additional support in the front for one more 360mm. The neat thing is, you can hide both of them if you desire, and still install the fans on either the inside or outside. The Pandora also comes with an integrated reservoir mounting system in its roof. For anyone not interested in the rigor and expense of liquid cooling, there's still ample room for both traditional tower coolers and AIO solutions, too.

MATERIAL WORLD

However, the Pandora isn't without its caveats. As we mentioned earlier, the choice of material is one of them—the steel side panels feel flimsy. And the rest of the case is made from a type of ABS plastic that feels a little too brittle for our liking. On top of that, the pop hinges, although simple in design, don't provide much of a handhold when it comes to shifting this beast around. BitFenix has somewhat remedied this by installing a grip in the back of the chassis, but it doesn't give you much confidence when trying to hold on to the front of this substantial chassis as well.

All in all, the Pandora ATX is a nicely rounded mid-range ATX tower, filled with innovative features to support water cooling and provide you with a particularly easy, clean building experience. The dust filters located under the PSU, on the roof, and in the front panel are intuitive, and help to keep it clean, and for the price, it's hard to beat. **–ZAK STOREY**

VERDICT
8

BitFenix Pandora ATX

+ **HESIOD'S THEOGONY** Intuitive design; vast water-cooling support; solid price; power supply cover; easy building.

− **DULL POEM** Materials could be better; outlandish aesthetics.

$110, www.bitfenix.com

SPECIFICATIONS

Form Factor	Midi tower
Motherboard Support	ATX, microATX, Mini-ITX
Colors Available	Black
Window Available	Yes
3.5-Inch Support	x4
2.5-Inch Support	x4
Radiator Support	280/360mm roof, 120mm rear, 280/360mm front
Fan Support	3x 120mm roof, 1x 120mm rear, 3x 120mm front
Dimensions	8 x 20.1 x 22 inches
Graphics Card Clearance	17.3 inches
CPU Tower Clearance	6.3 inches
Weight	25lb

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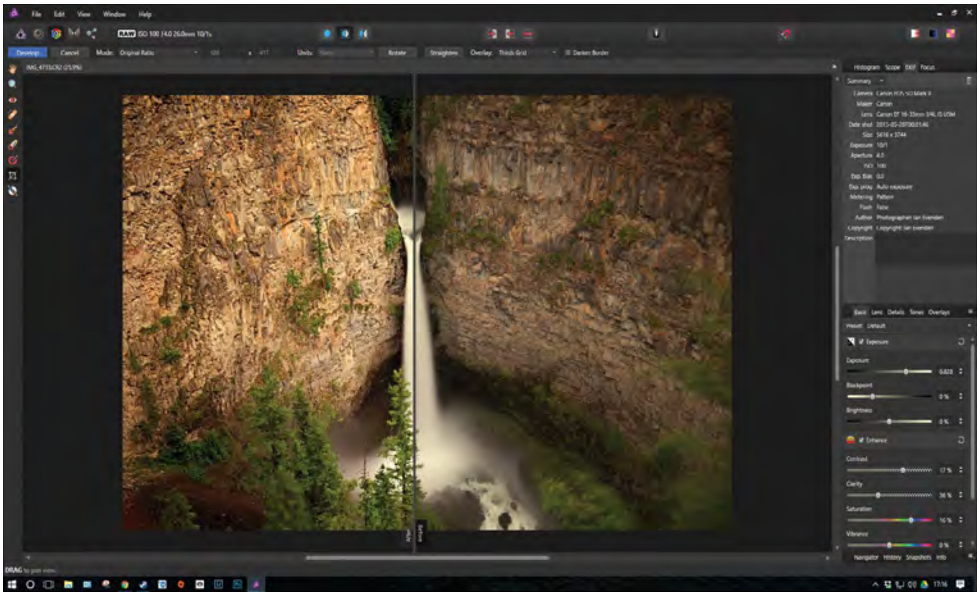

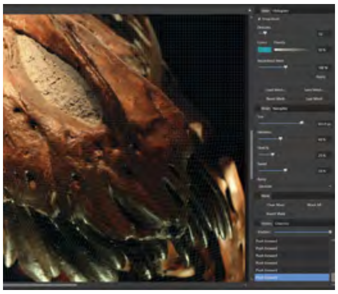

Affinity Photo 1.5

Pro image editing at a reasonable price

THE NAME SERIF has long been associated with budget design apps, usually ending with "Plus." There was DrawPlus, PhotoPlus, and even PagePlus, and while they were cheap, they were outclassed by other software packages, often costing a great deal more, and which ran on Macs.

While the products improved over time, Serif decided to break with the Plus range when it launched Affinity Designer, a vector graphics app that was initially released only on Apple computers, followed by Affinity Photo, a raster-editing app. Both then made their way to Windows after beta periods (in the case of Affinity Photo, a very short one, as anyone trying to follow last issue's tutorial may already have found out).

The Affinity products are pro-grade, Adobe-troubling apps sold at a reasonable price, with no monthly subscriptions. If you can do it in Photoshop, the chances are you'll be able to do it in Affinity Photo, although sometimes without the same levels of user-friendliness we've come to expect from Adobe's more mature product, and sometimes with remarkable levels of thought put in by Serif's engineers. The benefit of the year it spent as a Mac exclusive, though, is that the thick-black-framed-glasses brigade has done the beta testing for us.

Affinity is split into parts known as "personas," each of which has its own workspace that has a slightly different layout and function. Things are in the same general places, but tools you need in one persona aren't present in another. Opening a raw image file takes you to the Develop persona, and when you've finished with your adjustments there, you move it into the Photo persona for more edits. There's an Export persona for creating files matched to specific requirements, Liquify for distortion and warping effects, and Tone Mapping for HDR image creation. The chances are you'll spend most of your time in Photo, and Develop if you shoot in raw. Switching between personas is a simple case of clicking an icon at the top of the interface—the change is instant, and your image moves over with edits intact.

RAW POWER

Develop only operates on one image at a time, like Adobe Camera Raw, rather than Lightroom. It's a full-featured raw image converter, with a Clarity slider that's capable of extracting more detail from your images, and a useful split view showing your image before and after your edits, divided by a bar that can be dragged across the image with the mouse, to show the full scope of your changes.

The Photo persona is where the bulk of the editing is done, and while anyone who has used Photoshop or Photoshop Elements will feel at home, there are some differences that can take a while to get used to. The tools live on the left, with a selection of floating palettes docked on the right, where you'll find common actions such as Levels adjustments and Hue/Saturation. Affinity also has a top toolbar, populated by automatic adjustments, such as Auto Levels, plus selection and pasting tools. Filters live in their own menu, and as the app supports layers, there's a palette of that name with a familiar layer stack, and buttons at the bottom for creating new layers, masks, and so on. Liquify acts like Photoshop's Liquify filter, enabling you to drag areas of your image around as though it were made of soft clay, making invisible changes or more caricaturish edits.

If you're looking for a photo-editing app to get started with, Affinity makes a lot of sense. It's cheaper than Photoshop Elements or a year of Photoshop CC's photographers' bundle, and while it lacks those packages' organizational abilities—it's not going to help you make sense of a vast photo library—its editing skills stand alongside Adobe's finest. **–IAN EVENDEN**

VERDICT
8

Affinity Photo 1.5

+ INFINITY Great image-editing package; raw processing; many Photoshop-like skills.

− DEBILITY Photoshop pros will be irked by the ways it doesn't ape Adobe's product .

RECOMMENDED SPECS 4GB RAM; DirectX 10 compatible GPU; 64-bit Windows.

$40, www.affinity.serif.com

Welcome
TO
THE PIER
SPECIALS
DESSERT
Player3

Raise your wanted rating high enough, and other players can invade your city to hunt you down.

Watch Dogs 2

Heroic hackers hound corporate bullies

A GAME IN WHICH you spend 30 hours conspiring to bring about a giant DDoS attack by getting people who like you to backdoor their own PCs and phones may seem like it's casting you as the bad guy, as would the beatings you hand out to security guards. But as you're sticking it to a large corporation that keeps records of people's private lives, you get some rebellious cool points that elevate you to hero status.

Watch Dogs 2 takes a trip through the headlines of today's and tomorrow's news sites, having you hack emails and take on corporate interests for the presumed benefit of San Francisco's grateful citizens. It's presented as an open-world stealth game, as you use your hacking powers to move unseen through the environment by taking over cameras and opening electronic locks from afar. It undoes this by requiring your physical presence at keyboards and terminals, meaning you must make your way there past the NPC guards you could circumvent by piloting one of your drones.

Despite three-word backstories for you to read while you drain their bank accounts, most NPCs are a bit robotic. Remote-controlling a forklift truck to run over and kill the director of a really bad movie alerts the security guards just fine, but they're more interested in the guy in the hoodie watching them from afar than they perhaps should be. Leave your car blocking the road, and they patiently queue for hours like they're British or something, or loiter in the doorway of a shop watching the fallout from an explosion you set off earlier (we have questions about how you hack pipes, but given that you re-route power supplies by playing *Pipe Mania*, perhaps it shouldn't come as such a surprise) until you get frustrated and drive a motorcycle through them. Then, someone round the corner dials 911, and the police kill you.

If some of this is starting to sound a bit like a *GTA* game, that's because Rockstar's series is the obvious point of comparison, as you steal cars to get around and carry out phoned-in missions. While your aims are more altruistic than Franklin and Trevor's, you can still go blasting your way through, thanks to a monstrous 3D printer at your home base, capable of churning out as many shotguns as you can afford.

Being a Ubisoft open world, there are innumerable side missions to distract you along the way, and these help drag out the running time. It's a long game by modern standards, and you'll have seen all it has to offer long before the end—although being able to fake a criminal record or shady past so your target is arrested or rubbed out by the mafia rarely fails to amuse. The game's systems, however, are just a little too shallow to keep sustained interest for the entire running time. –IAN EVENDEN

VERDICT
8

Watch Dogs 2

+ CANINE Bustling open world; great views; plenty of missions.

− BOVINE Stupid NPCs; grating humor; curious take on morality.

RECOMMENDED SPECS Intel Core i5-3470 or AMD FX-8120, 8GB RAM, GeForce GTX 780 or Radeon R9 290 with 3GB VRAM.

$60, www.watchdogs.com, ESRB: M

The Winter Update added this cutesy gingerbread village.

Some rides are a recipe for vomit.

Buildings and trees attract more visitors.

Everything is better with pirates.

Planet Coaster

In this park, there's always room for high rollers

SUNNY SKIES have been missing from videogames for much of this century, so any opportunity to escape the grimdark worlds of *COD* or *Gears of War* is welcome. This month's other game review, *Watch Dogs 2,* presents players with a suitably sweltering San Francisco, but no game can match *Planet Coaster* for sheer summer fun.

Another thing we haven't seen much of, unless you're into soccer or farming, is management games. 2013's *SimCity* wasn't a huge success, and now Frontier is resurrecting theme park management.

And what a resurrection. *Planet Coaster* is sunshine collected and condensed into something endlessly entertaining, a game dedicated to making people happy, rather than making them dead. Frontier's experience with *Rollercoaster Tycoon 3* and *Thrillville* shows through, and across the Career, Challenge, and Sandbox modes, there's a wealth of imagination and friendliness on offer.

Building rides is fiddly due to the need to run paths to and from the ride's entrance and exit. For the entrance, a special "queue path" is needed, while any old path will do for the exit. This isn't obvious if you haven't watched the tutorials, which are hosted on YouTube, and open in a browser window on the game's opening screen. Doing it this way takes agency away from the player, and isn't really a substitute for a proper tutorial. You can work through the easiest scenarios to pick up the basics, but when something doesn't click, like the queue paths didn't for us, frustration can set in.

The rest of the time, building your park is a breeze. Sandbox mode allows you to alter the terrain, leveling it under rides, and creating the perfect slope for a large rollercoaster. Rides are built from blueprints, apart from the large rollercoasters, which are bespoke, assembled from a kit of parts, and graded on the excitement, fear, and nausea they provoke. The key to a great coaster is to get a balance of the three, and a heatmap is provided during testing to show where the puke may fly, but it's always wise to hire janitors to clear up spillages in the exit path, and mechanics to make sure things don't get too frightening. Then there's trash cans, restaurants, restrooms, and decorations. Almost everything can be customized, down to the text on signs. The emphasis is shifted hard toward creation and pleasing the crowds, and away from hard business choices, and it's all the better for that.

The game is a wonderful slice of summer in these dismal winter months, a relaxing experience that will last late into the night, and proof of how much fun it can be to make little computer people happy. **–IAN EVENDEN**

VERDICT
9

Planet Coaster

+ INVERTED Jolly and simple fun; bright and breezy graphics; huge amounts of coaster customization.

– SUBVERTED Irritating theme tune; watching the tutorials is a must; Winter Update slightly nauseating.

RECOMMENDED SPECS Intel Core i7-4770 or AMD FX-8350; 12GB RAM; 4GB Nvidia GTX 980 or AMD R9 380.

$45, www.planetcoaster.com, ESRB: E

LAB NOTES

BO MOORE, TECHNOLOGY EDITOR

Gaming On the SLI: The Dual Duel

Is two always better than one?

Expensive? Absolutely. Better value than SLI? Possibly.

I'VE BEEN CHATTING with the team a lot about high-end builds. The current debate is whether or not such systems should opt for a single GTX Titan X or a pair of GTX 1080s. I've always assumed that the dual-card setup would perform better, and at a lower price, but after finally having the chance to try both options out, I'm beginning to lean toward a single Titan as the way to go.

Why? Because SLI is a nightmare to work with. Not only does it lead to more system instability, it's also a complete crapshoot in terms of performance output. Depending on the game and resolution, not only did a second GPU often not give me the performance increase over a single card you might expect, I sometimes found that the dual-card setup performed worse than if it were a single GPU pulling all the weight. To make matters worse, SLI does not play nice with DirectX 12, and is useless for games using Unity or Unreal Engine. Meanwhile, the dearer Titan X performs admirably in almost every situation, despite technically not being a "gaming" GPU.

The only situation we've found where dual 1080s are better is when gaming at 4K. For all its power, the Titan X doesn't have enough juice to consistently hold 60fps at 4K at max settings in the most demanding games. Dual 1080s seem to be able to pull that off much better (provided the game supports SLI). But is it worth the lack of support and sense of uncertainty that comes with SLI? I think no. The solution? Get a single Titan X and game at 1440p. Instead of fooling with SLI or 4K, opt for a G-Sync enabled high-refresh monitor and thank us later.

ALAN DEXTER

Executive Editor

As is normal for the holiday break, I found myself acting as tech support to my extended family. One interesting report was from my brother-in-law who had upgraded his system, but wasn't confident in his ability. "Should I move my RAM to improve airflow?" "Why aren't my graphics card fans running?" "Does this BIOS message mean my graphics card isn't working properly?" The questions came thick and fast, but these were little more than niggles, and the reported temperatures and frame rates proved nothing was wrong with his upgrade. It's important to know when something isn't right with your system, but at the same time, it's important to not worry about something, until it really is a problem.

JARRED WALTON

Senior Editor

2016 was pretty awesome, particularly in the graphics arena, but the CPU world wasn't as exciting. The reason is simple: GPUs handle massively parallel sets of data (graphics), while CPUs are tasked with trying to be the best jack-of-all-trades solution. With clock speeds only improving by small amounts, it's far easier to scale performance with GPUs than CPUs. Kaby Lake and Zen aren't likely to change things, but if you have an older CPU, this should be a good year for a platform upgrade. Meanwhile, I'm still waiting to see a production sample of Intel and Micron's 3D XPoint Technology, which was quietly moved from a late 2016 release to sometime in 2017.

Editors' Picks: Digital Discoveries

Tuan Nguyen, editor-in-chief, and Zak Storey, reviews editor, peer into the future

OCULUS RIFT LENS INSERTS

One of the most annoying things about VR goggles is using them with glasses. This is why I stopped using my Rift and Vive headsets after just two weeks of play time. If you wear contact lenses, though, you're fine.

But now there's a solution for us glass-wearing folks: VR Lens Lab, a company in Europe that produces prescription lens inserts. The company takes your glasses prescription and creates custom lenses that fit over the lenses in the Rift and Vive. They clip to your VR headset and deliver crisp, clear vision. VR Lens Lab can even provide you with lenses if you have astigmatism.

I customized my lenses for the Rift, as that's the headset I use most often. You can customize your lenses to be plain-Jane lenses, or with options such as high-index, premium lenses, and something the company calls Blueguard Coating—which reduces strain from blue light. Damage came in at a very reasonable $100.

I went from virtually zero use to using the Rift every day. If you wear glasses, and love VR, you need these. VR Lens Lab currently only makes lenses for the Rift and Vive, so if you intend on using, say, a Samsung Gear VR, you're out of luck.

$100, http://vr-lens-lab.com

CORSAIR & 0DB FAN TECHNOLOGIES

I am obsessed with noise, or the lack of it. I started 2016 with a fully liquid-cooled machine, propped up by the magnificent power of the Noctua NF-F12 iPPC 2,000rpm fans, and a Corsair AX1200i. However, after a fitting failure, I decided to scrap it in favor of an AIO alternative and an aftermarket GTX 1070.

However, it still wasn't quiet enough, so I purchased the Corsair ML120 Pros for my new build. On top of that, I installed a massive Corsair HX1000i PSU, as I knew it took advantage of 0dB fan tech until it reached 50 percent load. The difference is astronomical. Running the three ML120s off the NZXT Kraken X62 means they run whisper silent, and are easily configurable in the CAM software suite. I have them running at around 40 percent load, and can barely even hear them. The two GPUs also feature 0dB fan tech, and as I lack any spinning platter hard drives, noise is almost non-existent. At least, until I start typing.

Is this the end of my noise pursuits? Likely not. While the Corsair ML120 Pros are the things my dreams are made of, keeping the din of the GTX 1080s down while gaming is impossible. The solution may well be another go at hardline liquid-cooling.

$25-760, www.corsair.com

GEEK TESTED & APPROVED

Creative Outlier Sports

"BLUETOOTH SPORTS HEADPHONES? What is this? A lifestyle mag?" Don't worry, we haven't gone mad. Creative dropped by last month to show off its new hardware, and chief among other crazy offerings, such as an RGB LED lit soundbar, were these dainty Bluetooth headphones.

Why did I decide to take a look? Well, I'm a bit of a mountain bike junky. Crashing very expensive carbon fiber bikes down particularly gnarled hills is how I get my kicks. And to do that, I need to train. Currently, I use a pair of $15 Sennheiser MX 365 in-ears for my gym work, and although the bass is plentiful, and the sound quality quite charming, they do have a habit of falling out when I'm lying flat-back on a bench.

Because of this, I decided I'd give these little beauties a shot. They're available in green, black, or orange, are sweat-proof (up to IPX4), boast an impressive 11-hour battery life, come with an integrated mic for calls, and are held in place by two terrifying rubber hooks.

As far as audio is concerned, the Outliers are fairly well balanced. They do need a bigger presence in terms of bass and mids, but it's still an enjoyable experience. My biggest gripe rests with the plastic-coated cable, which refuses to lay flat on your neck. Are they worth $70? It depends if you have the cash. They definitely offer some ease of access, but the nuisance of having to charge them every few days puts me off replacing my trusty Sennheiser MX 365s just yet. **–ZS**

$70, www.us.creative.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Overclocking Dual Cards
> Cleaning Out PCs
> Budget Builds

Overclocking SLI

I love your magazine. As a constantly deployed US Navy sailor, it is always great to see when it comes into my ship. Your article on overclocking was great in December 2016. Very clear and precise, and better than scouring forums.

On to my questions: I have two Nvidia GTX 980 SCs in SLI. Do I need to overclock them both individually using the steps you provided? Or can I just do one, and then apply the same settings to the other card? Can I use MSI Afterburner as you guys suggested, or do I have to use EVGA's software? MSI's looks more user-friendly than the EVGA software I have (and kind of hate).

–Nikolai "MUFFS" L.

REVIEWS EDITOR ZAK STOREY RESPONDS: When it comes to overclocking two graphics cards, you can either treat them individually, or as a pair. If you use MSI Afterburner, you have the option of keeping the cards either linked together or not—this isn't related to SLI or CrossFire, merely overclock settings.

In the default view, where your card's name is stated, click the tab that says "GPU." This lists all the cards you have installed in your system. There should be a little up and down line symbol to the right of each card—if you want to just apply one lot of settings until either of the cards gives way, make sure that the two lines are identical, and that there's two white dots by both the cards' names. Hit "Apply," and your overclock profile is applied to both cards simultaneously. If you're curious about whether you've lucked out a bit more on one than the other, you can do the opposite, and manually overclock both, by clicking those two lines again, then swapping between each card using the tab, and applying the settings in the UI as normal.

Regarding the EVGA software, I'm totally with you—I can't stand it most of the time. It can be a little trickier with brand new cards to find a tool that unlocks the voltage; EVGA's was the first, so it was our natural port of call. That said, like you, I find MSI's far more user-friendly. Hypothetically, you can use any overclocking software you want, on any card, regardless of brand. Some come with certain security locks in place to make sure you don't damage third-party cards, but otherwise you should be fine.

With MSI Afterburner, if you want to unlock the voltage controls outside of power limits, click the settings cogwheel, then in the third subsection of the "General" tab, you should see a checkbox that says "Unlock voltage control." Make sure it's checked, then click the drop-down box and (specifically for your EVGA 980 SCs) change it to "Third party." It asks to restart the application, and you're good to go.

Dust Devil

I am going to be doing one of my favorite(!) jobs later today—cleaning all the dust and gunk out of my desktop rig. Though this thing lives in a fairly clean environment, it does get dirty. So, I got to thinking: There has to be a simple and reasonable way to filter all the air the fans are blowing through my rig so I can cut my cleaning back to... Never! How about an article sometime with some practical suggestions on how to do this, short of disconnecting my blowers?

–Garth Cooper

REVIEWS EDITOR ZAK STOREY RESPONDS: At *Maximum PC*, all of our systems run what we call positive-pressure fan setups. In essence, every place we can install a fan, we do so, and in a way that means it's drawing air into the chassis. That way, all the air entering the case is filtered first, and the air inside the case is pushed out of all of the unfiltered gaps, holes, and cracks, stopping dust entering the system as easily, at least while it's running.

I used to run a balanced system, but noticed that I was cleaning it out with a can of pressurized air every couple of weeks. After swapping to positive only, I could get away with just doing it every month or so with the same results.

That said, if you're after a quick fix, and don't fancy messing around with your fan orientation, you can always buy fan filters online. Silverstone sells the FF143B and the FF123B, which are fine gauze 140/120mm, respectively, magnetic black fan filters, and they only cost around $7-8 each. Just search Newegg or Amazon for "Silverstone fan filter," and they should come up. I use two of these in my own

↘ submit your questions to: comments@maximumpc.com rig, one for the rear fan and one for the roof fan of my NZXT S310 Elite.

Budget-Busting

Thanks for your "Linux Budget-Busting Box" article in the January issue. It has inspired me to finally replace my Linux computer I built based on the "Building the $300 Budget PC" article from the January 2006 issue of *Maximum PC*. It is still chugging along after more than 10 years. It has seen a lot of iterations of Linux in that time, and is currently running OpenSUSE 13.1.

I want the new computer to be as small as possible, but still have a slot for a DVD burner, so I am looking at the Mini-ITX In Win BP655 case. The CPU will be the same as the one you used—Core-i5 6500. Using Mini-ITX really cuts down on my choices, but I think I will go with the Gigabyte GA-Z170N-WIFI Mini-ITX motherboard. I don't need Wi-Fi or Bluetooth, but this mobo has a DVI-D port for my old monitor. No GPU, just integrated graphics.

I'll probably use the same Samsung PM961 256GB M.2 drive you used, without any HDD at all. My old Linux PC only has an 80GB hard drive, and I didn't fill it up in 10 years, so 256GB will be plenty. I've been reading that these M.2 drives can get really hot. It will be mounted on the back of the Gigabyte motherboard, and then the motherboard will be mounted in the case. There are no airflow holes on the back of the In Win case. I'm afraid there just won't be enough airflow to keep the M.2 drive cool. Do you think this is really going to be a problem? Do you have any suggestions? **–Mike Hamm**

REVIEWS EDITOR ZAK STOREY RESPONDS: I understand your pain when it comes to Mini-ITX boards. I've always been a big fan of them—in fact, I've got a real soft spot for Micro-ATX, too—but you're right, there's certainly not a lot of them out there. That said, the GA-Z170N is a solid motherboard. We've played around with a few Z170 motherboards this year, and Gigabyte has produced some of our favorites.

With regard to thermal throttling and M.2 drives, it is true they do have a habit across the board of doing so. In fact, even Samsung claims that its best 960 Pro M.2 drives begin to throttle once they've transferred beyond 333GB. Some brands are better at countering this than others, and we are aware of motherboard manufacturers trying to combat this with some intuitive new features included in their Z270 offerings (which we can't, unfortunately, talk about just yet). However, this thermal throttling generally only occurs in high usage scenarios, mostly when you're transferring huge files, or running excessively aggressive benchmarks for prolonged periods of time. For day-to-day operations, running an operating system such as Debian or OpenSUSE in particular, you shouldn't have any problems whatsoever.

To clarify, the liquid-cooled hard-piped machine I pieced together in our July issue used a Samsung 950 Pro drive tucked away behind the motherboard, and I never had any issues with it whatsoever, outside of some flaky boot times brought about by a suspect BIOS update.

One-Sided

So, here's the thing. I am not an obsessed fan of either Nvidia or AMD, but do find it a bit annoying when one is included while the other isn't. Case in point: The gaming system upgrade you recommended in the January 2017 issue for the graphics card was the Nvidia 1060, with no mention of the RX 480. Why is that? The 1060 has a limited system life. No DX12 or SLI support, so the 480 is more future-proof as it offers both. If you consider the cost, the RX 480 is about 30 to 40 bucks cheaper, which could be spent on an aftermarket cooler like the CoolerMaster Hyper 212, and then playing with the CPU overclock. Anyway, would sure like to see you mention both options in any future upgrade issues. Otherwise, great issue, as always.

–Kent Durgen

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: While certainly an interesting discussion, the merits of the RX 480 over the GeForce GTX 1060 wasn't really the point of the upgrade feature—it was about the process of upgrading, and what choices we would make with certain systems. For us, the GeForce GTX 1060 got the nod, because it offered better value for money—the RX 480 may be cheaper, but the GTX 1060 offers better performance, and ultimately provides a higher frame rate for each dollar spent.

The DX12 argument is mostly moot because there are still very, very few DX12 games around, and there isn't a compelling performance delta for those titles that do exist. As for SLI, while we do lament the lack of support on the 1060, it still wouldn't sway us from our decision—we've suffered enough SLI/CrossFire woes in our time to still be sceptical of its true usefulness.

You're obviously free to pick whatever hardware you want for your upgrades. Whether you use an RX 480, a 1060, or a Titan X is purely down to your preferences. The case studies are simply illustrations of what we would do, and we would pick the same hardware if we were to repeat the process today.

[NOW ONLINE]

AMD ANNOUNCES RADEON INSTINCT

RADEON INSTINCT

We recently attended the AMD Tech Summit, a now-yearly event where AMD details some of its upcoming products, and frequently demonstrates working prototypes. Now we can officially talk about a new brand: Radeon Instinct. Radeon Instinct is AMD's alternative to Nvidia's Tesla line of products, though the previous FireStream (discontinued in 2012) and FirePro lines competed in this market as well. What makes Instinct different is the focus on machine intelligence, which in this case equates to running the calculations required for deep neural networks. Read the full story online at http://bit.ly/2j3YMG6.

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» Get 1,000s of awesome apps
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THE BUILDS

BUDGET

MID-RANGE

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Evolv ITX	$70
PSU	EVGA 450B Bronze	$45
Mobo	Gigabyte GA-H110N	$90
CPU	Intel Core i5-6500	$205
GPU	Zotac GeForce GTX 1060 Mini 3GB	$195
RAM	8GB (2x 4GB) Crucial Ballistix Sport LT	$53
SSD	240GB SanDisk Z410 2.5-inch SSD	$70
HDD	1TB Hitachi 7,200rpm 3.5-inch SATA	$40
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $784

THE GORGEOUS EVOLV ITX CASE sets the ball rolling this month with a price hike of $10. An increase that is continued by other components to set a bleak tone for anyone looking to build our budget machine—although, if things are really tight, you should check out our main feature on building a super-budget PC, on page 26. The Gigabyte motherboard saw a $15 price bump, while the Zotac GTX 1060 saw a $10 increase as well. Normally, we would look for alternatives for these core components, but as we're waiting for Kaby Lake to really shake things up, we'll avoid any serious changes right now. At least the outgoing Skylake Core i5 hasn't been affected, and remains steadfast at $205. Finishing off the rather grim news, we saw price increases for the RAM and SSD, too, meaning that overall this machine costs $46 more this month than it did last. For the exact same hardware.

INGREDIENTS

PART		PRICE
Case	NZXT S340 Elite	$100
PSU	Corsair RM650x 650W 80 Plus Gold	$70
Mobo	Gigabyte GA-Z170XP-SLI	$110
CPU	Intel Core i5-6600K	$250
Cooler	Corsair H100i v2	$103
GPU	EVGA GeForce GTX 1070 SC Gaming ACX 3.0	$380
RAM	16GB (2x 8GB) G.Skill NS Series DDR4-2400	$95
SSD	250GB Samsung 850 EVO M.2	$97
HDD	Western Digital Black Series 1TB 7,200rpm	$74
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,379

WHILE THERE WAS LITTLE POSITIVE NEWS for the pricing of our budget system, things get off to a much better start with our mid-range PC. Corsair's impressive RM650x is a healthy $30 cheaper this month, and the EVGA graphics card also saw its price squeezed, giving us a $20 saving over last month's pricing. That's $50 before we really get started. We did see minuscule price increases for the SSD and hard drive, but nothing to get too upset about. RAM continues its upward trend, though, with the G.Skill NS Series costing $15 more this month. Looking around for alternatives proved that this trend is universal, and as we're loath to go with no-name brands, we'll stick with these for now. So, no changes on this machine either, but we did do a major overhaul of the system last issue, and with a major shake-up coming in the form of Ryzen, we're happy with the price-performance ratio of this machine right now.

TURBO

WHEN IT COMES TO OUR TURBO BUILD, we're less concerned about hitting a specific price point, and more focused on getting as close as possible to best-in-class performance—without completely nuking the bank. This lead to a couple of tough decisions, as there have been a few movements on the core components. For reasons that aren't too clear, pricing on GTX 1080 graphics cards has increased substantially—at least 10 percent. This meant that our previous choice wasn't as competitive, so we've switched to a Gaming X rendition of Nvidia's top-end mainstream GPU. This still represents a $50 increase over last month's card, but demand for 1080s doesn't seem to be diminishing, which is why prices are continuing to rise. We did see a big-name GTX 1080 in a dull shroud for less than $600, but for that sort of cash, we weren't confident enough in its cooling capabilities to recommend it. The other area that saw a sizable price increase was the SSD, namely the 1TB Samsung 960 Pro. An $84 hike in a month is hard to swallow, and we were tempted to find an alternative, drop the capacity, or switch to the EVO, but just couldn't. Truth is, the 960 Pro is an incredible drive, and given the impact it'll have on your machine, there isn't a realistic alternative. Other than that, pricing was fairly stable, with a $10 reduction in Intel's 6800K a nice bonus—signs of Intel responding to the might of Ryzen? We jest, but expect some movement when AMD does get its chips out.

For more of our component recommendations,
visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Evolv ATX		$170
PSU	EVGA SuperNOVA G2 750W		$100
Mobo	MSI X99A SLI Plus		$228
CPU	Intel Core i7-6800K		$440
Cooler	Corsair H100i v2		$103
GPU	MSI GeForce GTX 1080 Gaming X 8GB	**NEW**	$650
RAM	32GB (4x 8GB) Corsair Vengeance LPX DDR4-2400		$220
SSD	1TB Samsung 960 Pro M.2 NVMe SSD		$714
HDD	2x 2TB WD Black 7,200rpm 3.5-inch SATA		$230
OS	Windows 10 Home 64-bit OEM		$100

Approximate Price: $2,955

UPGRADE OF THE MONTH

MSI GEFORCE GTX 1080 GAMING X 8GB

We are in a relative lull in the graphics card market—the full line-up of current-gen cards has (mostly) been released, so it's a case of picking a winner and settling in with it. The GTX 1080 has the lead, and until the 1080 Ti comes out (rumored to be March) that isn't going to change. So if you need a graphics card now, and have the money, these 1080 Gaming Xs get the nod from us. We used them in last year's Dream Machine, and they pack an incredible punch. Vega and Volta are around the corner, but something new and exciting invariably is in this market....
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Maximum PC (ISSN 1522-4279) is published 13 times a year, monthly plus Holiday issue following December issue, by Future US, Inc., One Lombard Street, Suite 200, San Francisco, CA 94111. Phone: (650) 872-1642. Fax: (650) 872-2207. Website: www.futureus.com. Periodicals postage paid in San Bruno, CA, and at additional mailing offices. Newsstand distribution is handled by Curtis Circulation Company. Basic subscription rates: one year (13 issues) US: $24; Canada: US$40; Foreign: US$40. Canadian and foreign orders must be prepaid. Canadian price includes postage and GST (GST #R128220688). PMA #40612608. Subscriptions do not include newsstand specials. POSTMASTER: Send changes of address to *Maximum PC*, PO Box 5852, Harlan, IA 51593-1352. Standard Mail enclosure in the following editions: None. Ride-Along enclosure in the following editions: None. Returns: IMEX Global Solutions, PO Box 25542, London, ON N6C 6B2, Canada. Future US, Inc. also publishes *@Gamer*, *Mac|Life*, *The Official Xbox Magazine*, and *PC Gamer*.

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